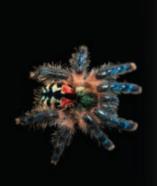
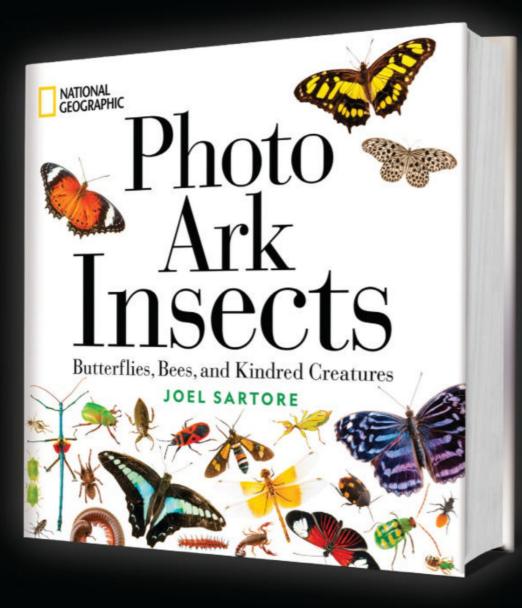




# BUG OUT!

From the glorious monarch butterfly to the spiny Australian katydid, from the tilted head of a praying mantis to the delicate wings of a dragonfly, here are Joel Sartore's exquisite portraits of the insects, spiders, and related creatures that fly, burrow, scurry, squirm—and share this planet with us.

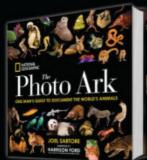






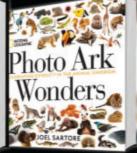


I ALSO AVAILABLE FROM JOEL SARTORE









NATIONAL GEOGRAPHIC

**PHOTOARK** 





I AVAILABLE WHEREVER BOOKS ARE SOLD











#### CONTENTS

#### On the Cover

Monarchs mass together for warmth and security during the night in their wintering grounds in Mexico's Monarch Butterfly Biosphere Reserve.

PROOF

EXPLORE

10



THE BIG IDEA

We Need Play, Seriously It's time well spent, researchers say. Having fun is actually fundamental to the survival of our species. BY SADIE

10

In Search of Still Lifes

By showing elements of ecosystems, a Canadian photographer fosters greater appreciation for nature's smaller things. PHOTOGRAPHS BY JULYA HAJNOCZKY

BREAKTHROUGHS

DINGFELDER

On the Coat Tales
Not one but two spotless giraffes have been
recently spotted.
BY DINA FINE MARON

THROUGH THE LENS

A Gift, When It
Mattered Most
During a difficult photo
assignment, salvation
came from the pope.
TEXT AND PHOTOGRAPH
BY DAVE YODER

ALSO

Tiny Turtle Robots



30

INNOVATOR

Ara Kusuma
She's helped more
than 4,500 children
in Indonesian villages
get access to highquality education.
BY CATHERINE
ZUCKERMAN

CLOSER LOOK

Trailing the Royals
Centuries-old footpaths
offer spectacular
glimpses into Hawaiian
culture and history.
BY CATHERINE
TOTH FOX

ALSO

A Tooth as Hearing Aid?



#### F E A T U R E S

#### Flight of the Monarchs

These butterflies get a boost from scientists and citizens. BY MICHELLE NIJHUIS PHOTOGRAPHS BY JAIME ROJO......P. 36

#### Reproductive Revolution

Technology is pushing the limits of fertility. BY REBECCA TUHUS-DUBROW PHOTOGRAPHS BY JACKIE MOLLOY......P. 68

#### **Between Two Worlds**

In the Amazon, a tribe uses modern tools to protect its traditions. STORY AND PHOTOGRAPHS BY LYNSEY ADDARIO.....P. 94

#### A Fragile Fabric of Living Things

The U.S. Endangered Species Act has aided at-risk wildlife for 50 years. BY NATASHA DALY PHOTOGRAPHS BY JOEL SARTORE......P. 108

#### **Treasure Island**

Solo sojourns in an uninhabited place bring a sense of freedom. STORY AND PHOTOGRAPHS BY JASPER DOEST.....P. 118

**ABOVE:** Harbor seals, as well as migratory birds, flourish on the Dutch island of Rottumeroog, part of a protected wilderness in the Waddenzee. Access to the island is granted only rarely and by special permit.

# DIRIAH THE CITY OF EARTH



**DIRIYAH.SA** 





BY NATHAN LUMP PHOTO GRAPH BY JAIME ROJO

**AT NATIONAL GEOGRAPHIC**, we talk a lot about "charismatic species," a loose term used by conservation biologists to describe animals that have the broadest public appeal. Because they hold our attention, animals such as tigers, elephants, and gorillas are influential in provoking thought, discussion, and action around conservation.

Few insects would be considered charismatic, but one that does fit the bill is the subject of this month's cover story: the monarch butterfly. Monarchs are both beautiful and, in their own way, magical. Each year eastern North American monarchs complete a seasonal migration of up to 3,000 miles, traveling from the United States and Canada to wintering grounds in Mexico. (You can learn more about the migration in an episode of our series *Incredible Animal Journeys*, streaming on Disney+.)

The monarch's need for specific plants throughout this vast migratory range has made it particularly vulnerable to environmental degradation.

In our story, photographer Jaime Rojo documents the monarch with spectacular images, and writer Michelle Nijhuis tells the tale of passionate scientists and volunteers who are working diligently to ensure its future.

This issue also coincides with the 50th anniversary of the Endangered Species Act, passed by the U.S. Congress with bipartisan support. Since the law's creation, 64 species, including the bald eagle, have recovered, but the list of species deemed in need of protection has dramatically expanded, from 124 to more than 2,300. To mark this moment, we've included a selection of portraits of endangered species from National Geographic Explorer Joel Sartore, who has captured images of thousands of animals as part of his ongoing Photo Ark project.

We hope you enjoy the issue.

After their long journey south, monarchs gather by the millions in a high-elevation fir forest in the El Rosario Sanctuary, located in the Mexican state of Michoacán. The butterflies seek out groves used by previous generations in earlier years.

N-



FROM THE CEO OF THE NATIONAL GEOGRAPHIC SOCIETY

## Saving Endangered Species, Saving Ourselves

TICK. TICK. PZZZZ. The song of the Florida grasshopper sparrow is unusual and surprisingly insect-like. But it almost fell silent forever. In 2012 National Geographic Explorer and Photo Ark founder Joel Sartore received a call from the U.S. Fish and Wildlife Service: The songbird, an important ecological link in Florida's dry prairies, was teetering on extinction. With only a few dozen males showing up in counts, it was among North America's most endangered bird species.

Funded by a National Geographic Society grant, Sartore flew to Florida to photograph the bird and work with conservationists to raise awareness of the species' plight. The story appeared in *Audubon* magazine and other outlets, helping boost government funding for a breeding program. Thanks to these steps, there are now as many as 180 adults in the wild, and researchers are working hard to bring the species back from the brink of extinction.

Like other examples of species survival, the push to save the sparrow is "a remarkable story of conviction and collaboration," says Sartore. It also shows what it takes to protect an endangered species: research, compelling narratives, partnerships, resources, and time.

This journey embodies the Society's mission to illuminate and protect the wonder of the world. Over the past 136 years, we've developed a unique Explorer-led model, combining science, exploration, education, and storytelling to drive impact. We support Explorers in more than 140 countries, including Sartore and others whose work appears in this issue: biologist André Green II; photographers Lynsey Addario, Jasper Doest, and Jaime Rojo; and education advocate Ara Kusuma.

The issue also celebrates those who've spent years galvanizing change for endangered animals. A half century after the passage of the Endangered



Species Act, the Society remains deeply committed to inspiring action and hope for decades to come.

Sartore is now 17 years into his quest to create an "ark" of animal photos. Portraits of more than 15,000 species invite audiences to connect and care. With the Society's support, the images have graced iconic landmarks and U.S. postage stamps, prompting on-theground conservation efforts such as National Geographic's Photo Ark Species Impact Initiative.

As Sartore says, "The sounds of birds are the sounds of a healthy planet. When we save a bird or another species, we're actually saving ourselves."

Jill Tiefenthaler, CEO National Geographic Society The National Geographic Society recently launched the Hope for Species campaign, celebrating the 50th anniversary of the Endangered Species Act. The law helps protect animals that are vital to their ecosystems, such as the Florida grasshopper sparrow (below).





Rebecca Tuhus-Dubrow
From her home in California,
Tuhus-Dubrow often writes
about the intersection of society and technology. She's the
author of Personal Stereo, a
cultural history of the Walkman,
and is working on a book about
nuclear energy. Her articles
have run in outlets such as Slate
and the Guardian. Page 68



Jackie Molloy
Molloy, a photojournalist in New
York City, frequently focuses
on the complex and evolving
nature of family. During the
COVID-19 pandemic, she documented at-home births for
National Geographic. In 2022
she was featured in the "30: New
and Emerging Photographers
to Watch" program. Page 68



Michelle Nijhuis
Based in rural Washington
State, Nijhuis writes about conservation and climate change, including National Geographic feature stories on the Mekong River and the future of America's national parks. She authored the book Beloved Beasts: Fighting for Life in an Age of Extinction. Page 36

#### NATIONAL GEOGRAPHIC EXPLORERS

These contributors have received funding from the National Geographic Society, which is committed to illuminating and protecting the wonder of our world.



#### **Joel Sartore**

A conservation photographer who's contributed more than 40 stories to the magazine, Sartore lives in Nebraska, near his childhood hometown. He roams the globe for his Photo Ark project, aiming to make portraits of at least 20,000 animal species, with the goal of inspiring people to protect them. An Explorer since 2012, Sartore was named Rolex National Geographic Explorer of the Year in 2018. Page 108



#### Lynsey Addario

"I don't cover conflict just to cover it. I cover it because I think the stories within that conflict need to be told," Addario says. The Pulitzer Prize winner has told those stories through her camera in places from Afghanistan to Iraq. Author of the bestseller It's What I Do, Addario became an Explorer

Geographic Society's Eliza Scidmore Award for Outstanding Storytelling in 2022. Page 94



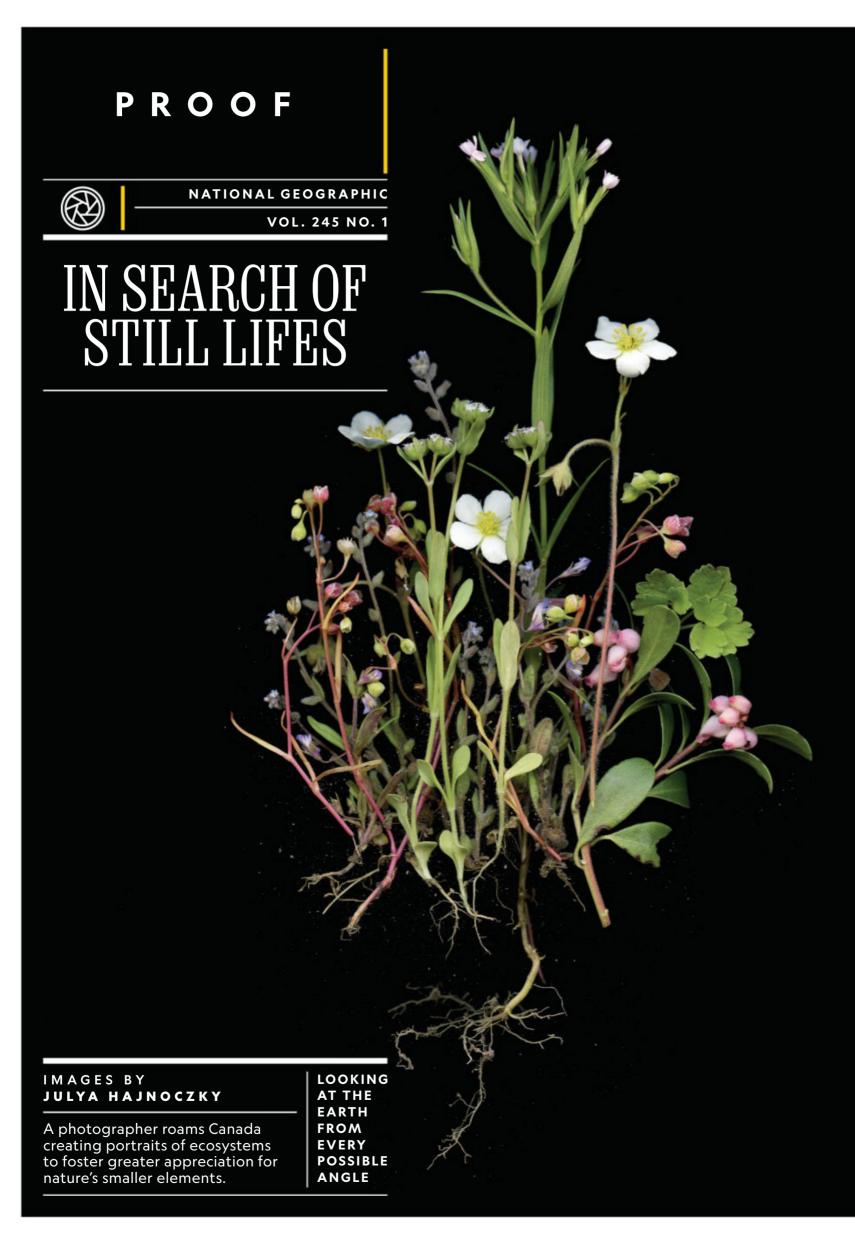
#### Jaime Rojo

An Explorer since 2020, Rojo is a photographer from Spain who specializes in stories about wilderness, wildlife, and people. Ultimately, he hopes his work can inspire the creation of new protected areas. A Senior Fellow of the International League of Conservation Photographers, he has been given honors in competitions including the World Press Photo Contest and Wildlife Photographer of the Year. Page 36



#### Jasper Doest

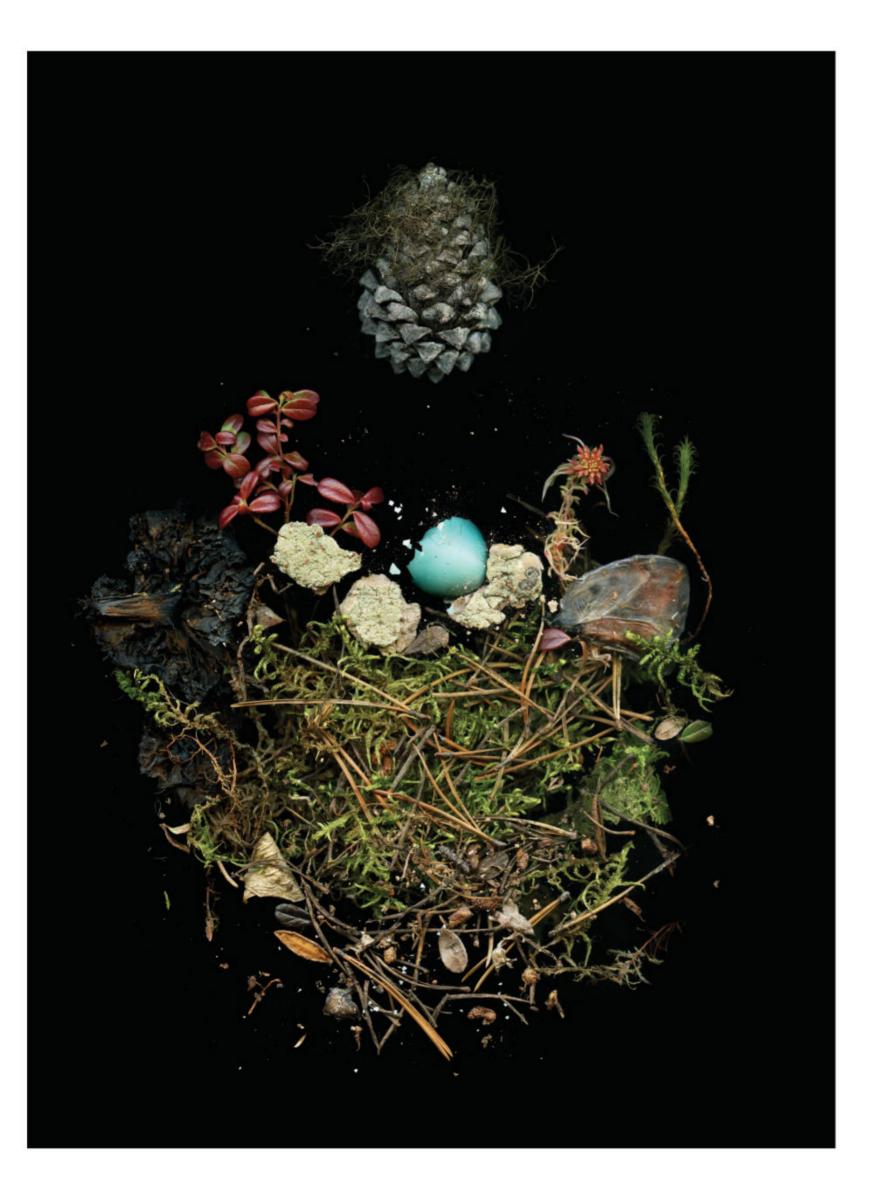
Doest is a Dutch photographer who explores connections between humankind and the natural world. His *National Geographic* stories include features on forest elephants and a rescued flamingo named Bob. An Explorer since 2022, Doest has won four World Press Photo Contest awards and was named Environmental Photographer of the Year by the Prince Albert II of Monaco Foundation in 2023. Page 118







Hajnoczky researches each ecosystem and collects representative items. Arranged here for imaging on her scanner: eelgrass and the empty shells of a snail and a California mussel from a beach at Pacific Rim National Park on Vancouver Island.



An assemblage from Pierre Grey's Lakes Provincial Park includes a lodgepole pine cone, pine needles, and part of a robin's eggshell. Hajnoczky travels with a trailer that does triple duty as sleeping quarters, laboratory, and imaging studio.



By leaving her scanner's lid open, Hajnoczky adds a black background to objects, and they appear to float in an outer space-like void. Anchoring this image is a lichen, gathered in the Rocky Mountains, with an imaginative name: fairy puke.



"I spend a lot more time looking around a place than I do collecting things," Hajnoczky says. Eventually an arrangement takes shape. She's especially drawn to what she calls "charismatic microflora," such as the willowy seed heads of mountain avens.

### THE BACKSTORY

HIKING AT A SNAIL'S PACE GIVES THIS PHOTOGRAPHER TIME TO DOCUMENT THE LITTLE THINGS BEFORE IT'S TOO LATE.

A SERIES OF FROGLIKE crouches. A personal best time of four hours on a typically 15-minute trail. This is how Julya Hajnoczky describes her slow and unconventional mode of hiking. For weeks each year, the Calgary native creeps along footpaths in some of Canada's most stunning wild spaces. She hovers over moss or mushrooms while other visitors speed by. "It must be how cyclists feel on the highway when they're getting passed by semitrucks," she says. Sometimes, though, hikers stop and ask what she sees that they don't. She's happy to explain—after all, that's the point of her project.

In 2017 Hajnoczky designed and built an eight-foot-long mobile trailer, which she dubbed the Alfresco Science Machine. Painted forest green, it houses an inventory of fieldwork immersion: a bed, a camp kitchen, binoculars and hand lenses, collection permits, field guides, vials and specimen-collection tools, sunscreen, bug repellent. Also evident? Hajnoczky's foraging ethics: Pick a minimal amount of abundant, dead, or discarded things—never rare species or live animals—and return them when finished.

The resulting portraits, rendered on her high-resolution scanner, are the Canadian landscape in miniature and make up her ongoing project: At the Last Judgement We Will All Be Trees. Deeply concerned about humanity's relationship with the environment, Hajnoczky characterizes the images as "elegiac, dark, mourning," as still lifes created while there's still life. Yet they're also enchanting. Slow down, they seem to say. Look with wonder at the natural world and see the urgency to protect it. —HICKS WOGAN



In the Kootenay Ranges of British Columbia, Hajnoczky gathered a plethora of cones.

#### EXPLORE

IN THIS SECTION

Spotless Giraffes Spotted Historic Hawaiian Trails Access to Education Present From the Pope



ILLUMINATING THE MYSTERIES-AND WONDERS-ALL AROUND US EVERY DAY

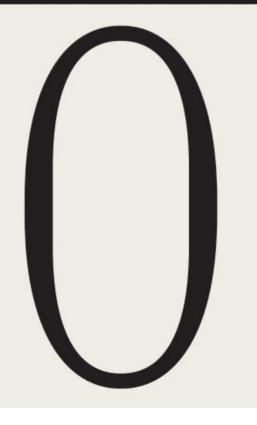
NATIONAL GEOGRAPHIC

VOL. 245 NO. 1

# We Need Play, Seriously

ADULTS TEND TO DISMISS IT AS SILLY OR CHILDISH, BUT HAVING FUN MAY BE FUNDAMENTAL TO THE SURVIVAL OF OUR SPECIES.

BY SADIE DINGFELDER



**ON THE RARE OCCASION** that a snowstorm blankets Washington, D.C., the city is transformed: The National Mall becomes a moonscape, the monuments turn alien, and the U.S. Capitol morphs into a castle on a cloud. When I awoke to this captivating scene one December morning, I immediately put on my warmest clothes and dashed outside. I wanted to build a snowman, but no matter how gently I rolled my snowball in the glistening fluff, it refused to grow. Defeated, I collapsed onto the powder with my arms and legs splayed. Since I was already halfway to a snow angel, I windshield-wipered my limbs to finish the job.

Then I noticed I had an audience—a prim-looking couple with Starbucks cups in their gloved hands. Disapproval wafted off them like steam from their lattes. My face flushed with shame as I stammered an answer to their unspoken question: *Don't you have anything better to do?* 

A middle-age woman playing by herself in the snow

#### PLAY MAY LOOK FRIVOLOUS, BUT RECENT STUDIES INDICATE THAT FOR MAMMALS AND PERHAPS ALL VERTEBRATES, IT MAY BE AS ESSENTIAL AS THE NEED FOR SLEEP.

is an undeniably odd sight, but maybe it shouldn't be. New research suggests that modern adults are suffering from a surfeit of somberness. We've suppressed our natural play instinct, and that's causing all kinds of problems—for ourselves, our children, and our planet.

"The opposite of play isn't work; it's depression," says psychiatrist and play researcher Stuart Brown. "The adult-play deficit is becoming a public health crisis." Play may look frivolous, but recent studies indicate that for mammals and perhaps all vertebrates, it may be as essential as the need for sleep. Just last summer, scientists found that the play drive originates in the brain stem—in evolutionary terms, one of the oldest parts of our nervous system. You can take out a rat's entire cerebral cortex, and it will still want to play. Playfulness helps some young animals learn to master their bodies and their environments—and once they do, most stop playing as adults. However, there are a handful that never stop—a group that includes wolves, crows, dolphins, monkeys, humans, and other primates—and biologists are only beginning to figure out why.

One possibility is that adult play can lead to useful discoveries, a theory supported by a study on Bali's long-tailed macaques. For her doctoral thesis at the University of Lethbridge, animal researcher Camilla Cenni left two types of puzzle boxes for the monkeys to solve. To get to the food inside, they had to either drop a rock into the container or use it to hit the box. She found that the macaques that previously had been observed dropping rocks for fun were more likely to solve the rock-dropping puzzle, while those that had discovered the joy of clacking rocks together came up with the answer to the percussive puzzle.

This finding also suggests that somewhere, deep in our evolutionary history, a playful proto-human came up with the concept of stone tools. Even today, the urge to play underlies most of humanity's greatest inventions, artworks, and scientific breakthroughs, Brown says. "When I interviewed Nobel laureates, I was struck by how most of them didn't separate work and play. Their labs were their playgrounds," he says.

While object play occasionally results in direct applications, it has a more general benefit as well, says animal behaviorist Marc Bekoff. "Most forms of play are about preparing for the unexpected by expanding your behavioral repertoire." When animals play by themselves—such as goats jumping around and intentionally landing awkwardly—they learn two lessons: how to recover from missteps and,

#### Playtime 101, for Adults

We grown-ups, with our grown-up responsibilities, often find it difficult to rediscover a childlike sense of fun. Here's how to start:

- Let yourself get bored. Turn off the television, chuck the cell phone, and welcome the wacky ideas that bubble up in your mind.
- Give yourself permission to be weird. Draw with your feet, turn a closet into a ball pit, or play mermaid in the bathtub.
- If you're feeling artsy, try making something impermanent, so you focus on the process rather than the end product. Build fairy houses in the woods out of natural materials, but don't take pictures.
- Invite free-spirited friends to ioin in the merriment. Invent new games with made-up rules.
- Host a dance party, but ask everyone to partner with a random object from your home.
- Feeling stuck? Improvisational games such as freeze tag and Fortunately, Unfortunately may help you loosen up. (You can find the rules online.) -sp



ILLUSTRATION: CARLO CADENAS JANUARY 2024 **21** 

more generally, how to remain calm when things go sideways. "Play gives you the opportunity to deal with uncertainty and surprise in a safe environment," Bekoff says. This explains why animals that occupy predictable niches don't play much as adults, while creatures that must innovate to survive do.

Octopuses are one good example of the latter. Soft-bodied and living among sharp-toothed sharks, they rely on creativity and improvisation to survive. As a solitary species, they are outliers. Most playful adult animals live in cooperative social groups. This observation has led biologists to discover what is perhaps the most important function of adult play: building and maintaining relationships.

Before wolves are accepted into a pack, they have to demonstrate that they know how to play. This is no mean feat. To keep roughhousing from turning into a real fight, both animals must keep running tabs on their playmate's emotional state. Over time, the cavorting helps wolves learn what specific individuals enjoy and what they don't. "A central feature of social play is self-handicapping," Bekoff says. "While play fighting, you'll see stronger animals rolling onto their backs and exposing their bellies, giving the weaker animals an opportunity to win." Social play is always cooperative; the goal is not to win but to keep the game going. If you don't want your playmate to quit, you have to take turns and play fair. As a result, social play reinforces the egalitarian aspects of wolf pack life.

Bonobos are some of the most egalitarian animals, and some of the most playful. This is no coincidence, says Elisabetta Palagi, a primate researcher at Pisa University. To roughhouse effectively requires a certain amount of vulnerability, so a successful play session strengthens bonobo relationships by building affection and trust. Female bonobos play much more than males, and this behavior is crucial to the maintenance of their matriarchal social structure. Palagi says. Attempts at dominance by lone males are immediately quashed by the collective force of the bonobo sisterhood. The power of play is also evident in bonobos' inclusiveness and adaptability, she says. "They are xenophilic, which means they are accepting of new situations and new individuals, maybe because they practice through play," Palagi says.

Adult play promotes inclusivity, cooperation, creativity, adaptivity, and egalitarianism—all qualities that we humans could use more of, says Jeff Harry, a play consultant. Unfortunately, social norms restrain our urge to let loose. "Being a playful adult is really stigmatized in our society," he says. "You don't want to feel irresponsible. You don't want people to think that you're childish."

It hasn't always been this way, says Peter Gray, a play researcher at Boston University. When Gray reviewed descriptions of the last remaining hunter-gatherer tribes, he noticed that they were often described as "good-humored," "always laughing," and "joyful." "What we would call work—hunting and gathering was fun," he says. "It was interesting, skilled, varied work." Not one of these hunter-gatherer tribes had a word for "toil" or "drudgery," he adds.

"It sounds like I'm romanticizing, but this makes evolutionary sense," Gray says. "Generally speaking, we like to do the things that are necessary for our survival. We like to eat. We like to drink water. We like to take care of cute little children." Humans took one giant step away from fun when we started planting crops, he says. Plowing fields and milling flour are strenuous, repetitive, and boring. Then we invented factories and lost sight of play entirely.

We may be able to reverse this trajectory, says Harry. As we fully transition to a knowledge-based economy, work and play are beginning to merge again. Some of today's most successful companies, such as Google and Apple, were started by people tinkering in their garages. Organizations like these understand the value of encouraging adults to play. In many cases, people aren't needed for routine, boring tasks anymore. "You need people who can invent new things, who can think of new ways of doing things," Harry says.

In the face of grave threats such as war and climate change, it's tempting to spiral into seriousness. But that's exactly the opposite of what we need to do. "Play is all about looking at a tough world with creativity and optimism. It gives us the ability to cooperate and get along with people who differ from us," Brown says. He goes so far as to declare that "adult play is necessary for our survival as a species."

The next time I'm caught playing, I know exactly what I'll say: "I am not wasting time, or acting immature. I'm goofing off for the benefit of all humanity. You're welcome." □

Sadie Dingfelder is a journalist specializing in animal behavior, neuroscience, and neurodiversity. Her first book, Do I Know You? A Faceblind Reporter's Journey Into the Science of Sight, Memory, and Imagination, publishes in June.

## Fun: Not Just for Mammals

In recent years, scientists have found examples of play behavior throughout the animal kingdom. They've observed tadpoles hitching rides on bubbles from aquarium

aeration stones and monitor lizards fetching soda cans like dogs. They've videotaped poison dart frogs wrestling and paper wasps play fighting. They've even caught

juvenile social spiders frolicking. Like unsupervised teenagers at a school dance, these spiders appeared to be practicing their mating moves. -sp



# DISPATCHES FROM THE FRONT LINES OF SCIENCE AND INNOVATION

#### Follow the leader

Plastic and light pollution on coastlines can make it difficult for newly hatched sea turtles to reach the open ocean. Help may come in the form of a tiny turtle robot, designed by researchers at the University of Notre Dame, that can guide hatchlings along a safe path. —ANNIE ROTH





ANIMAL GENETICS

## ON THE COAT TALES

TWO GIRAFFES, ONE IN THE WILD AND ONE IN CAPTIVITY, WERE SPOTTED WITHOUT THEIR SPOTS.

We all know the characteristic features of a giraffe: long neck, hornlike head protuberances, spotted coat. Well, not always. A giraffe missing spots was recently photographed for the first time in the wild. The unprecedented sighting, at a private game reserve in Namibia (above), occurred just weeks after another animal with similar coloring was born at a Tennessee zoo. No data suggest that a solid-brown coat is appearing more frequently than in the past, but it's a surprising coincidence, says Sara Ferguson, a wildlife veterinarian and conservation health coordinator at the Giraffe Conservation Foundation. The last reported all-browngiraffe sighting was in 1972, at a Tokyo zoo. Genetic mutations are the likely cause, but the animals don't seem to be at a disadvantage, says Derek Lee, a biologist at Penn State University who co-authored a 2018 study that found some aspects of giraffe markings are passed down from mother to calf. Are the all-brown giraffes truly spotless? Technically, Lee says, they're "one-spotall-over giraffes." - dina fine maron

HEALTH & MEDICINE

# Could a false tooth be a twofer?

A dental implant does the work of a real tooth, helping people eat, speak, and smile, but it also has the potential to help them hear, according to a study by scientists at Shanghai's Tongji University. They discovered that the jawbone transmits sound to the inner ear just as well as the mastoid bone, used by some hearing aids. The finding could lead to the development of dental implant hearing aids that are comfortable and discreet. -AR



# A Gift, When It Mattered Most

TEXT AND PHOTOGRAPH BY DAVE YODER



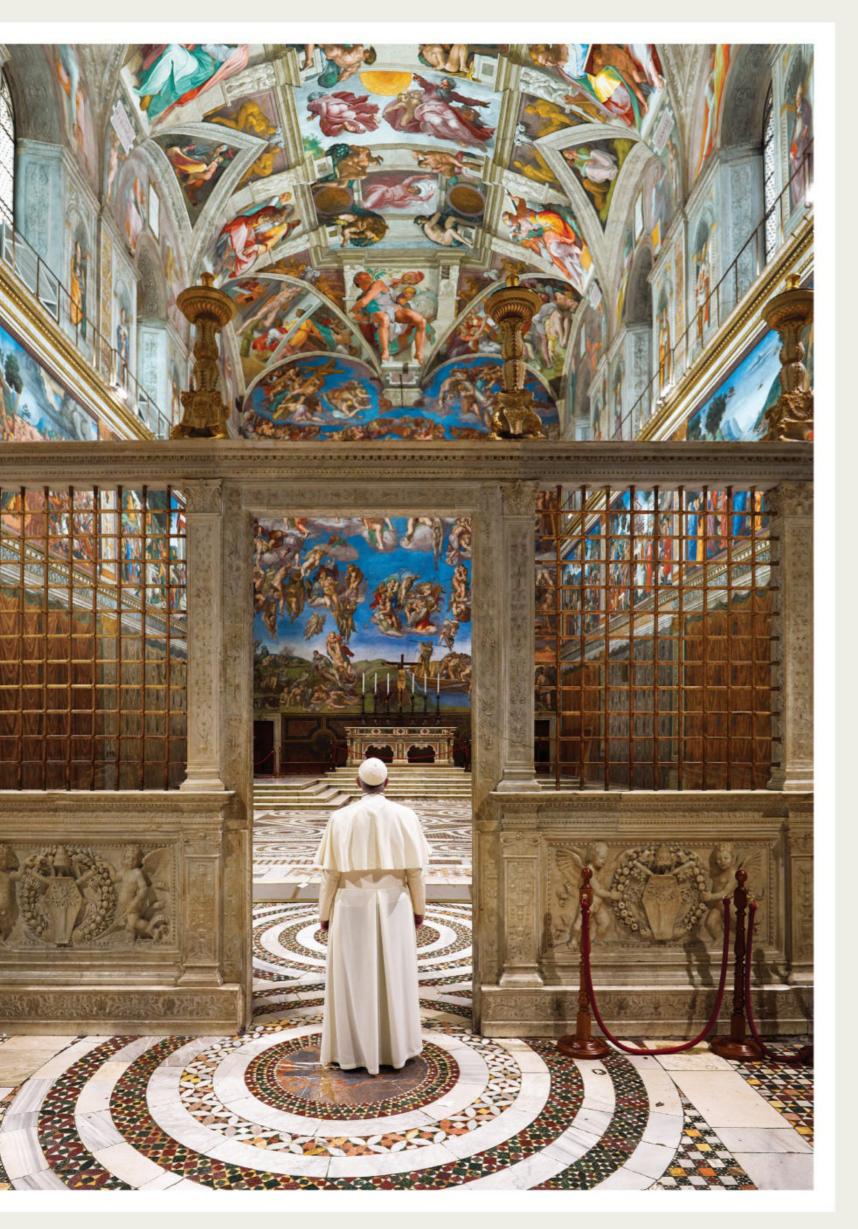
AFTER A PHOTOGRAPHER
RECEIVED HEARTBREAKING
NEWS DURING A DIFFICULT
ASSIGNMENT, HE WAS
DESPERATE. THEN POPE
FRANCIS TOOK A DETOUR.

THE BEST PICTURES ARE NOT TAKEN; they are gifts. Fittingly, this one arrived on Christmas Day in 2014. It materialized in the Sistine Chapel, miraculously, as if it had descended from Michelangelo's "Creation of Adam" in the ceiling above. But it came to me at a time so difficult that even today I question whether I should have been there at all.

Pope Francis had been elected the year before. Somewhat surprisingly, this plain, elderly man, who wished for a church that was "poor and for the poor," had become an international celebrity, a coveted subject for almost every major news organization. I wasn't at the top of anyone's list to photograph him. Although I lived in Rome at the time, I knew little about Vatican City or Pope Francis. But during a visit to National Geographic, I'd made an offhand comment about the pontiff to an editor. To my astonishment, he instructed me to shoot a story about the pope. I suddenly felt like the dog that had caught the car. I had no idea how to proceed.

I had to learn to navigate the Vatican. Journalists deluge the Holy See's press office with petitions for access. Success is limited; photographers are generally kept far from the pope. To aid my cause, I recruited then Editor in Chief Susan Goldberg, as well as all three U.S. ambassadors in Rome—the ambassadors to Italy, the Holy See, and the UN agencies located there—for a lunch with Vatican officials. My request was granted, but that proved to be only the first step in a monthslong process.

I was deposited among the Vaticanisti, the journalists who cover the pontiff, shooting the same imagery as everyone else. From that vantage point, the pope is a mere speck on marbled horizons. Then, as if in punishment for my sins, the magazine elevated the





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**INNOVATOR** 

## ARA KUSUMA

BY CATHERINE ZUCKERMAN PHOTOGRAPH BY REBECCA HALE



# She helps give children in Indonesia access to quality education.

At home in Jakarta during the COVID-19 lockdown, Ara Kusuma noticed kids outside during school hours. She remembers thinking, Shouldn't they be at home right now, attending online classes?

But then she realized that many children don't have access to the internet—or parents available to help them with their lessons. "Whether in a coronavirus situation or not," she says, "education poses certain challenges." UNESCO estimates that 250 million children worldwide do not attend school in person or remotely. Reasons range from conflict and discrimination to geography and lack of infrastructure.

This reality motivated 26-year-old Kusuma, a National Geographic Explorer, to launch the Aha! Project. The initiative aims to give children, regardless of background or location, access to high-quality education through low-tech tools and support from local volunteers.

To date, the Aha! Project has created and distributed home-education tool kits—which include worksheets, art supplies, and a learning guide—to more than 4,500 children across 64 villages in Indonesia. "Education is every child's right," Kusuma says. And as long as barriers to learning persist, she'll continue developing solutions to overcome them. □

The National Geographic Society has funded Ara Kusuma's work since 2020. Learn more about its support of Explorers at natgeo.com/impact.



Along a path used by ancient Hawaiians, the 3.5-mile trail to Ka'ena Point on O'ahu now follows a 19th-century railbed.

# TRAILING THE ROYALS

CENTURIES-OLD FOOTPATHS IN HAWAI'I, WHERE NOBLES ONCE STEPPED, OFFER GLIMPSES INTO THE ISLANDS' PAST.

#### BY CATHERINE TOTH FOX

**HAWAIIAN LEGEND TELLS** the story of the goddess Hi'iaka, who travels down a dusty trail on the windward coast of the Big Island of Hawai'i to a beach where she meets her sisters, including Pele, the volcano deity.

And there, on this remote beach in Puna, Hi'iaka danced what some consider the first hula.

The path to Hā'ena Beach, also called Shipman Beach, is still intact. Sometimes muddy and slippery, the 2.9-mile trail deposits visitors at an uncrowded shore known for its fine sands amid an otherwise rugged and rocky coast.

During ancient times, this was one of many footpaths (ala hele) across the Hawaiian Islands that linked coastal fishing villages. In the mid-1800s the trail was straightened and widened to accommodate horses and wheeled carts.

Eventually, as people moved inland, these seaside settlements were abandoned and the trail neglected.

Today few people who venture along the Puna Trail to get to Hā'ena's white sands know about its cultural importance. "It doesn't seem like much," says Jackson Bauer, who works for Nā Ala Hele Trail and Access Program, which manages public resources related to trail maintenance. "But imagine: Hi'iaka walked on that trail."

**ONE OF THE LAST** pieces of legislation approved by Queen Lili'uokalani, before the controversial overthrow of the Hawaiian monarchy, was the Highways Act of 1892. It states that any trail or road then in existence in Hawai'i belongs to the government, even on privately owned land. This further implies that these trails—which were used by ancient Hawaiians to gather food, wage battle, get to places of worship, and more—are for public use, accessible to all.



As a result of legislation by Queen Lili'uokalani, ancient trails in Hawai'i are state owned and may be publicly accessed.

This law came at a critical time for establishing Native Hawaiian land rights: In 1848 the Great Māhele, proposed by King Kamehameha III, redistributed about four million acres of land, abolishing the feudal system and leading to private landownership. Passed before Hawai'i became a United States territory and state, it ensured that the public—and most important, Native Hawaiians—could continue to visit cultural sites.

Thanks to the queen's foresight, the state now manages hundreds of miles of public trails that lead to heritage areas and native forests or follow meandering streams or tree-lined ridges. While many are now roads and highways—bustling Ala Moana Boulevard on Oʻahu, for example, was a centuries-old footpath that ran along the southern coastline—others are forgotten trails you won't find in hiking guidebooks. They're often not as popular as the more modern summit or ridge hikes with sweeping views and parking lots. But that's part of their appeal.

Identifying these footpaths and roads is an element of the Nā Ala Hele program's job. Staff pore over hand-drawn maps from the 1800s to find evidence of old trails in order to preserve them.

Ala Kahakai National Historic Trail (separately managed, partly by the National Park Service) is a 175-mile network that links communities, temples, fishing areas, and other sites on Hawai'i. Some parts of the network are thought to have served *ali'i* (Hawaiian royalty); other sections were for

messengers, who found it quicker to walk than to sail around parts of the island.

Another trail story tells of a swift runner who departed a village on the island's northwestern tip for Hilo and returned—about 80 miles each way through the interior of the island—to bring the king a fish from his fishpond; the fish was still alive.

"A lot of these ancient trails have been in use for more than a thousand years—and people still use them. That's the really exciting part," Bauer says. He points to major roadways on the islands, from the shop-lined Ali'i Drive in Kailua-Kona on Hawai'i to Pali Highway on O'ahu, which connects Honolulu with the island's windward side. "There's so much history along these trails, and we want to keep them alive."

WHEN MY SIX-YEAR-OLD SON and I hike along the wild coastline in Ka'ena Point State Park on O'ahu, we walk in the footsteps of ancient Hawaiians. The 3.5-mile trail to the point meanders through one of the last intact coastal sand dune ecosystems in the main Hawaiian Islands.

About 2,000 seabirds, including the Laysan albatross and the wedge-tailed shearwater, use Kaʻena Point as their breeding grounds. The area is also home to native wildlife, such as the great frigatebird and the red-tailed tropic bird, as well as critically endangered Hawaiian monk seals.

The path before us is lined with native coastal plants like beach *naupaka*, a shrub with small white flowers; '*ilima*, an indigenous ground cover with yellow flowers often strung in leis; and *naio*, or false sandalwood. We might pass a family fishing in a *moi* hole, a gap in the rocky shoreline where moi, or Pacific threadfin, can be found. Across the islands, moi—known for its slightly sweet taste and firm texture—was a fish often reserved for royalty.

I point out to my son places along the coast where his grandparents—my parents, who are at least third-generation *kamaʻāina* (Hawaiʻi-born)—would fish for *papio* (trevally) and even moi. (Restrictions on the fish were eventually lifted.)

The point itself is known as *leina-a-ka'uhane*, a leaping place of souls, where the spirits of the recently dead could be reunited with their ancestors. Here, the leaping place is a large, sloping rock facing the ocean.

"It's still there. You can still see it," says La'akea Perry, a *kumu hula*—master teacher of hula—who takes guests of the Four Seasons Resort O'ahu at Ko Olina on guided tours along the trail to Ka'ena Point. "When you walk there, it's like going to somebody's grave almost. You walk that path knowing that it's the same path spirits travel to get to their final point."

"People lived and died along these trails. They grew crops and accessed the ocean. They did everything here," says Bauer. "If there's a trail, then there's a lot more things nearby that need to be preserved. The trails provide the clues." □

Born and raised on O'ahu, **Catherine Toth Fox** is a food and travel writer, avid hiker, and editor at large for *Hawai'i* magazine.

## WALKING HAWAI'I'S HISTORY

Footpaths and trails, first protected by Hawaiian royalty in 1892, have grown into a network of 500 miles across six islands.

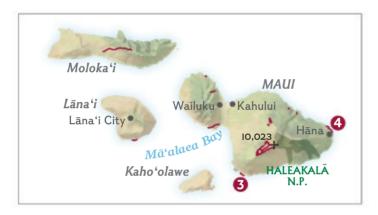


#### Nā Ala Hele trails



#### Elevations in feet







#### WHERE TO HIKE HAWAIIAN HERITAGE TRAILS

#### 1. Alaka'i Swamp Trail, Kaua'i

Sprawling over 4.345 acres in West Kaua'i, Kōke'e State Park has roughly 45 miles of hiking trails. Most notable is the seven-mile (round-trip) Alaka'i Swamp Trail, which follows the rim of Kalalau Valley into a rare montane bog environment some 4,000 feet above sea level. Along the way are native plants and trees, home to endemic birds including the 'elepaio (monarch flycatcher) and 'anianiau, a Hawaiian honeycreeper only found here. Hawai'i's Queen Emma visited the swamp on horseback in 1870. The setting so entranced her that she had her hundred dancers and musicians who traveled with her perform here before continuing on.

#### 2. Moanalua Valley, O'ahu

This hike can be as short or as long as you want, from an easy hour-long stroll along an old valley road to a grueling 11-mile trek to the summit of the Koʻolau Mountains. The first part—a cobbled carriage road-follows a stream and has interpretive markers. The road continues to Pōhakukaluahine, a sacred boulder covered with petroglyphs.

#### 3. Hoapili Trail, Maui

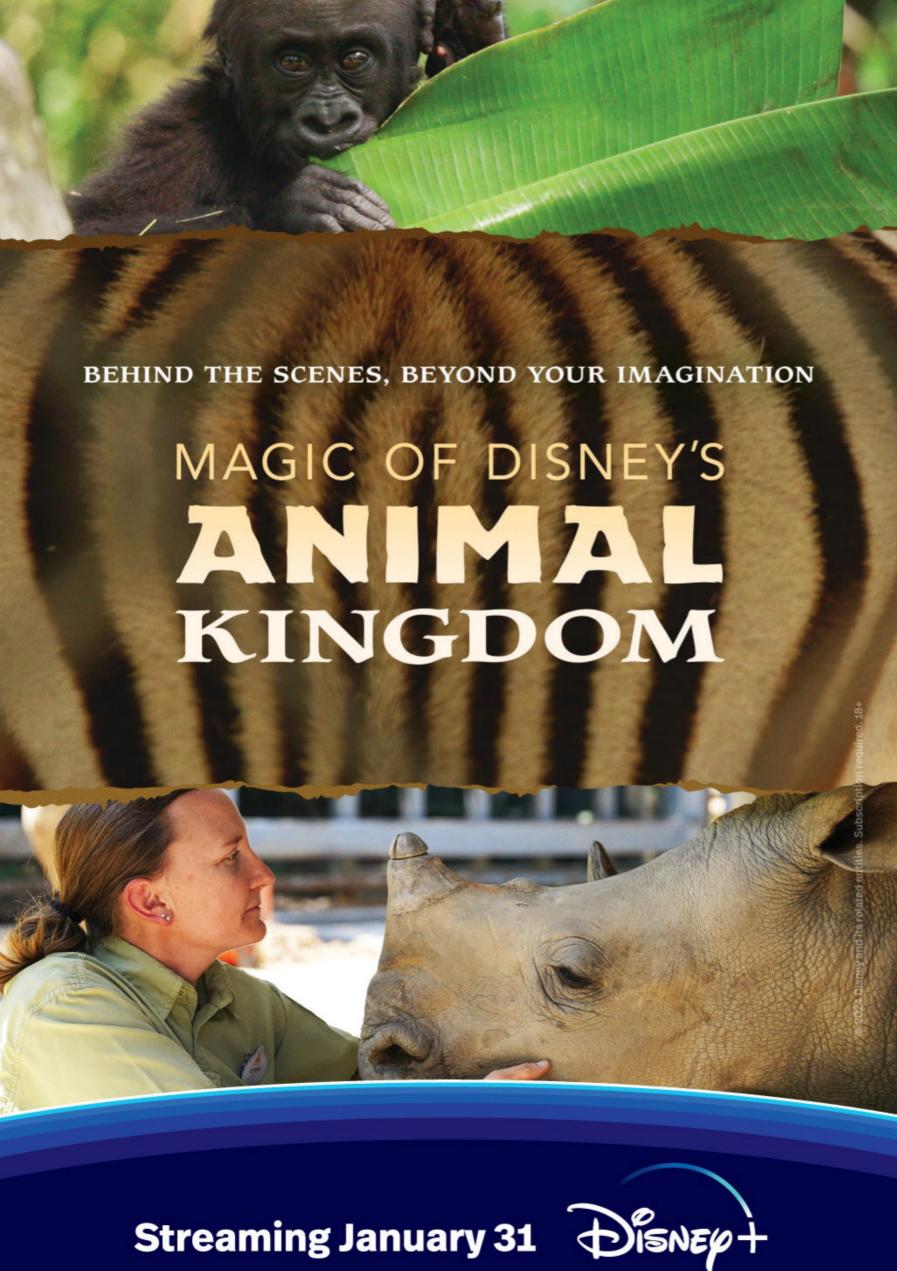
Part of this 12.5-mile trail follows an old footpath from Keone'ō'io Bay. Along the way you pass a native wiliwili (Hawaiian coral tree) and the last lava flow from Haleakalā volcano.

#### 4. Hāna-Wai'anapanapa Coast Trail, Maui

The 4.6-mile round-trip hike follows an ancient trail along the Hāna coastline in eastern Maui and is composed of rough aa lava. It's not as popular as nearby Pīpīwai Trail, but it takes in sea arches, tide pools, a blowhole, and a heiau—a religious site-before ending at rocky Ka'inalimu Bay.

#### 5. Pololū Trail, Hawaiʻi

This 1.2-mile out-and-back path takes hikers from the lookout down into the Pololū Valley, an elevation change of 878 feet over the course of the trail length. King Kamehameha I was born nearby in North Kohala.





#### JANUARY 2024

Monarch Butterflies....P. 36 Extending Fertility..... P. 68 Amazonian Tribe....... P. 94 Endangered Species.. P. 108 Alone on an Island.....P. 118

### FEATURES



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68

IN MANY PLACES WORLDWIDE,
PEOPLE ARE HAVING CHILDREN
LATER IN LIFE, OFTEN AIDED
BY SCIENCE. SINCE 1978, AT
LEAST 12 MILLION BABIES HAVE
BEEN BORN THROUGH IVF.







Right: In the butter-fly reserve, a single latecomer joins the others for the night, stretching its wings as it maneuvers in an attempt to squeeze into the popular roosting place. The butterflies' extreme closeness offers pro-tection and warmth.



# ON A HOT, CLEAR OCTOBER DAY IN TEXAS HILL COUNTRY, ANDRÉ GREEN II IS GENTLY SHAVING A MONARCH BUTTERFLY.

Bent over his makeshift laboratory bench, he deftly pinches the butterfly's bright wings between a thumb and forefinger, swiping a sliver of sandpaper down its thorax to remove a few minuscule hairs.

Green and his fellow researchers have set up temporary quarters inside one of the area's many private hunting lodges, and its walls are lined with the taxidermied heads of native and exotic game animals. But Green, a professor of ecology and evolutionary biology at the University of Michigan and a National Geographic Explorer, has eyes only for the three dozen monarchs he captured earlier in the day. He applies a dot of epoxy between the wings of the butterfly in his hand, then affixes a custom-designed sensor—a stack of computer chips powered by a miniature solar panel that together weigh less than three grains of rice. The soft flutter of wings is the only sound in the room.

This monarch and its companions, Green and his collaborators expect, will carry the sensors to the mountains of central Mexico, 800 miles south. In a few weeks, the researchers will follow the monarchs to Mexico, where they will try to detect the signals emitted by the sensors' antennas. If they can recapture one or more of the butterflies—a big if—they will be able to access the light and temperature data collected by the sensors en route,



José Humberto García Miranda of the El Rosario community in Michoacán plants oyamel fir saplings, which eventually will provide a winter home for migrating monarchs. To protect the saplings from extreme temperatures, "nurse plants" grow alongside them.

The nonprofit National Geographic Society, working to conserve Earth's resources, helped fund this article.



allowing them to map each butterfly's path.

Like other monarch research projects across North America, this one has been aided by volunteers eager to help the species. Green's colleagues, realizing that bicyclists travel at about the same speed as monarchs on the move, recruited cyclists to test the accuracy of the sensors by carrying them on multiday rides. Green conducted laboratory experiments to confirm that the sensors don't interfere with flight. Now, this novel technology is about to undergo its first real-world test.

When he finishes attaching the sensors, Green sits back in an overstuffed leather chair, surveying the butterflies in the net cage before him. "This year, we'll be happy if we pick up any kind of signal in Mexico," he says. Collecting meaningful data might require several more seasons of trial and error, but Green is patient. Smiling, he resorts to scientific understatement: "It's a real opportunity to understand this particular system."

As the day cools, Green carries the cage of butterflies outside, picking his way downhill to the pecan grove below the lodge. There, beside a creek, hundreds of migrating monarchs swirl through the lengthening light. Green extracts the sensor-carrying butterflies one by one, gingerly settling them on low-hanging branches like so many glass ornaments. Tomorrow morning, if all goes well, they will continue to venture south, taking their secrets with them.





HE SYSTEM THAT so fascinates
Green is one of the most epic, and
dangerous, journeys on the planet.
Though monarchs live throughout the world—in South America,
the Caribbean, Australia, Europe,
and elsewhere—North American
monarchs are distinguished by

their extraordinarily ambitious seasonal migrations. Each fall, monarchs in the northern United States and southern Canada fly south, the first relay team along a 3,000-mile route known only to earlier generations. Those that survive gather in central Mexico, where they spend the winter in the same fir groves that sheltered their grandparents and great-grandparents the previous year.

Despite decades of study, this annual ultramarathon—and the shorter migration of the continent's western population along the Pacific Coast—is only partly understood and ever more perilous. Due to climate change and habitat loss, monarchs on both migration routes are increasingly beset by extreme weather and scarce nectar sources. At the same time, the milkweed plants that breeding monarchs need to host their eggs and feed their caterpillars remain in critically short supply, diminishing overall numbers.

The prospects for North American monarchs are considered so dire that the International Union for Conservation of Nature (IUCN) has classified the two populations as vulnerable. They're now under consideration for protection by the U.S. Endangered Species Act. Those who have witnessed the populations' decline hope their new status will lead to sustained, multinational action: Karen Oberhauser, who has studied monarchs since the 1990s and recently retired as director of the University of Wisconsin-Madison Arboretum, says that since the monarch was first proposed for protection under U.S. law in 2014, the species has gained new support from government agencies and scientists. "The level of federal engagement has just skyrocketed, and that's been so important," she notes. "It's brought a lot of really smart people into our circles."

While the monarch is neither the largest nor the showiest butterfly in North America, no other insect—and very few species of any kind so captivates us. Its travels connect people across generations, national borders, and even, it is said, the barrier between life and death. Some Mexican observers of the annual Day of the Dead regard migrating monarchs as souls on the wing. Emergency workers in lower Manhattan during the days after September 11, 2001, saw the monarchs that sailed over ground zero as symbols of survival and rebirth. "When we say that this butterfly is 'iconic,' it is exactly that," says anthropologist Columba González-Duarte of the New School for Social Research in New York City. "It has a place now, for North Americans, as that insect that goes beyond borders, that is capable of the impossible."

Long before anyone understood how far North American monarchs travel, people celebrated their periodic appearances. Mexican poet and novelist Homero Aridjis, whose memoir recalls his childhood in the central Mexican state of Michoacán during the 1940s and '50s, wrote that the autumn wind "bore currents of butterflies." Aridjis and his friends would trek to a nearby mountain meadow to watch the butterflies alight in the firs, captivated by the spectacle.

In the 1950s, Canadian zoologist Fred Urquhart and his wife, Norah, founded the Insect Migration Association, beginning a long tradition of public participation in monarch research. Over the next several decades, the association recruited some 3,000 volunteers to capture individual butterflies and mark each with a tiny label reading "Send to Zoology University Toronto Canada." From the resulting data, the Urguharts surmised that monarchs spent the winter in Mexico, but didn't know where. In 1973, when they placed a call for volunteers in a Mexico City newspaper, Kenneth Brugger, an American expatriate, responded. Brugger's wife, Cathy, now Catalina Aguado Trail, had been paying close attention to monarchs and other butterflies since her childhood in Michoacán. She agreed to lend her language skills and knowledge of the region to the search for the monarch's wintering grounds.

For two years, first on weekends and then full-time, the couple crisscrossed the mountains of central Mexico by motorbike and on foot. On the afternoon of January 2, 1975, while climbing a volcanic peak called Cerro Pelón, Trail looked up into the firs and stopped short: The trunks and branches above her were covered with thousands of monarchs, so closely packed that their wings overlapped. When Brugger joined her, they both stood silently, awestruck.



#### A Geographic Legacy

In August 1976, Catalina Aguado Trail (formerly Cathy Brugger), surrounded by monarchs, appeared on the cover of National Geographic. Trail's two-year search for overwintering monarchs in the mountains of central Mexico ended in success in January 1975. The story announced that the winter habitat had been "discovered"—and Trail's finding filled a crucial gap in knowledge about the monarch's life cycle.

RAIL AND BRUGGER'S ELATION soon turned to worry. The monarch's winter habitat in Mexico is almost entirely limited to 10 or so small patches of high-elevation oyamel fir forest within an area of 217 square miles. In the 1970s, the local communities that hold communal rights to the forests depended on logging for a living, and the evergreen canopy that protects the monarchs from winter weather was shrinking fast. Crowds of curious visitors could further disrupt the habitat.

As word got out, tourists did travel to the mountains to gaze up at the monarchs. But the news also prompted action. The IUCN called on the Mexican government to protect the fir groves, as did the Mexican environmental group Pro-Monarca. Though the government established a national reserve that in October 1986 banned or limited logging in five of the known wintering grounds, the hoped-for economic benefits of tourism for local communities were spotty, and logging continued.

In 2000, after long and sometimes acrimonious debate among government officials, scientists, conservation advocates, and community representatives, the reserve was expanded threefold to encompass most of the monarch's known wintering habitat. The Monarch Fund—which is administered by the Mexican government and supported by international conservation groups—began making modest but consistent payments to the residents who hold rights within the core zone of the reserve, partially compensating for lost timber income and successful protection efforts. Around the same time, a group of Mexican

sustainable-development advocates founded the organization Alternare, which works with communities near the reserve on projects like reforestation and water conservation.

Thanks to these and other initiatives, logging in the reserve began to decline, and by the early 2010s, annual forest loss had fallen from hundreds of acres to single digits—a major conservation success. Since 2019, forest loss has once again increased, this time because of droughtdriven bark beetle outbreaks and the legal logging that is intended to control them. Part of the problem, says geographer Isabel Ramírez of the National Autonomous University of Mexico, is that state forest management policies haven't caught up with the changing climate.

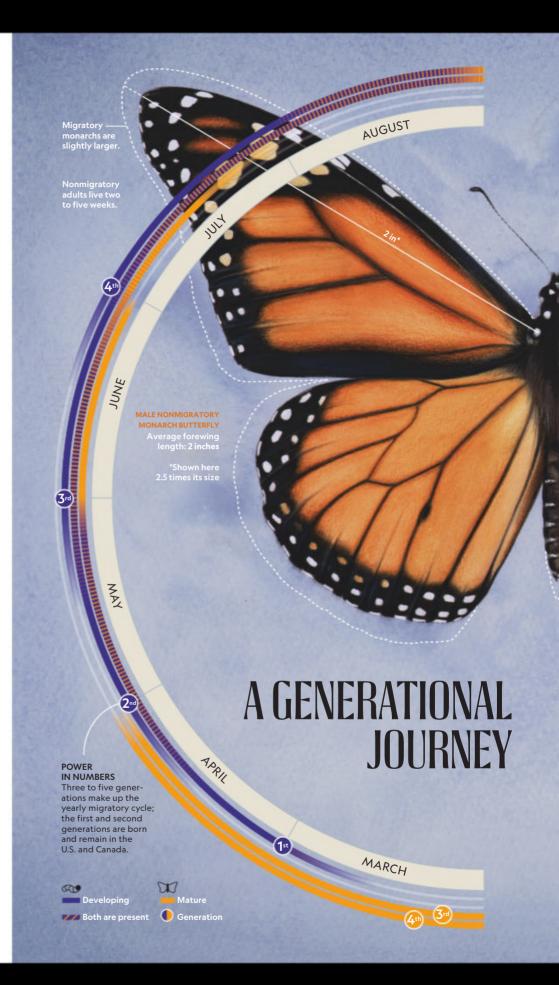
ARLY ON A December morning, I follow André Green and his team along a narrow trail into the Sierra Chincua monarch sanctuary in central Mexico. My first impression is that the tall, slender trees around us are covered with rusty foliage. When my eyes and brain catch

up to reality, I realize that every fir in sight is draped with slumbering butterflies, wings folded to display their paler undersides. The layers of insects are heavy enough to bend even the sturdiest branches. The cool mountain air seems to vibrate, stirred by the countless wings twitching above our heads.

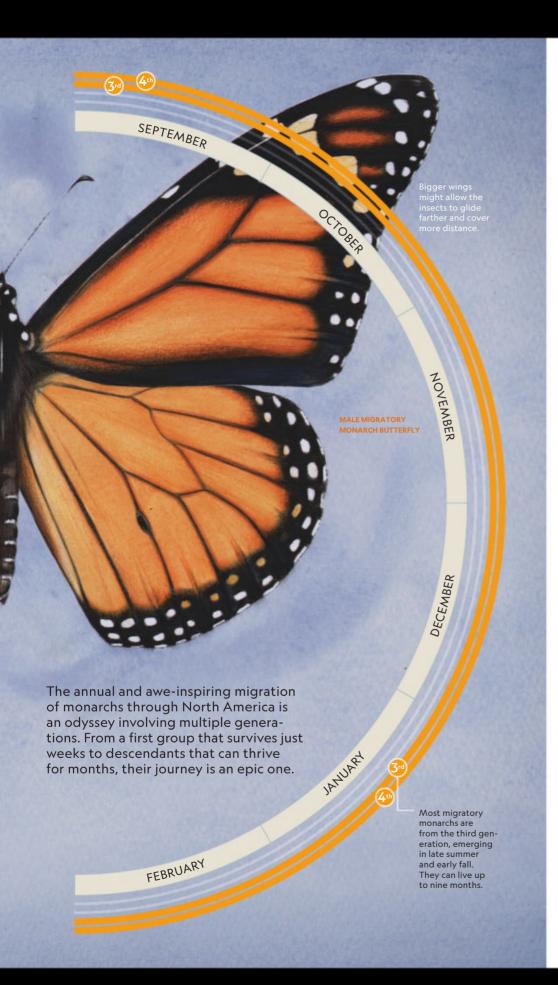
As the struggle to protect the wintering grounds unfolded in the 1990s and early 2000s, scientists from Mexico to Canada were working to understand the monarch's astonishing annual journey. Longtime monarch researcher Lincoln























Clockwise from top left: A female monarch near Ames, Iowa, forages for nectar sporting a movementtracking radio transmitter; at Texas A&M University, Christine

Merlin studies a monarch from her lab-raised colony as part of her research on understanding how the insects sense Earth's magnetic fields; migrating monarchs

near Monterrey, Mexico, overnight in the glare of city lights; "prairie strips" of native plants in an lowa field protect the soil, conserve water, and provide habitat.







You can learn more about the monarch's extraordinary migration—along with those of other animals across the globe-in our new series, *Incredible* Animal Journeys, now streaming on Hulu and Disney+. Brower and his colleagues learned that while the monarchs that overwinter in Mexico travel north in the spring, they don't complete the trip; they instead lay eggs in northern Mexico and throughout the southern U.S. When those offspring mature, they continue to the northern U.S. and southern Canada, also laying eggs along the way. During the summer, two or three more generations emerge. The final generation, unlike its predecessors, doesn't immediately reproduce but enters a state of suspended maturation called diapause. When the days begin to shorten and cool, these aging teenagers head south, returning to Mexico in a single generation.

Since these Mexico-bound monarchs can't ask their great-grandparents for directions to the winter colonies, scientists reasoned that they must be able to navigate. Through a succession of studies, researchers learned that monarchs are equipped with two compasses: a primary system that uses the sun and a backup system that uses the Earth's magnetic field.

In a study published in 2009, biologist Christine Merlin and her collaborators found that monarchs use circadian clocks located in their antennae to correct their sun-compass readings for the planet's daily rotation. While this elaborate system keeps monarchs headed in the right direction, it doesn't fully explain their ability to home in on the same circumscribed wintering grounds year after year.

In the Sierra Chincua sanctuary, the sun climbs higher above the horizon and the rustling in the trees increases. The monarchs open their wings to bask, warming their muscles in preparation for flight, and the whole forest seems to brighten. On the steep slope above the trail, one of the team's radio receivers stands ready to detect a sensor-carrying butterfly, just in case one has not only reached Mexico but chosen this stand of firs as a winter home. A few monarchs begin flitting from tree to tree, and soon we're surrounded by a muffled cacophony of millions of moving wings, a torrent that glows above and around us. Some of the monarchs stream out of the grove, while others weave through the trees, radiant in the filtered sunlight, occasionally dipping low enough to skim our faces and hands. All the while, though, the receiver remains silent.

Since returning to their laboratories at the Universities of Michigan, Delaware, and Pittsburgh, Green and his colleagues have improved the energy efficiency of the sensors, ensuring





## 'WE RECOGNIZE THAT THEY'RE FIGHTING FOR THEIR HABITAT AND THAT WE'RE HELPING TO BRING IT BACK.'

Halay Turning Heart, Muscogee Nation

that the solar panels will be able to harvest enough sunlight in the shady reserve forests. In October 2023, they attached 175 sensors to butterflies in Texas, boosting the chances of capturing a signal when they climb into the Sierra Chincua this winter.

"It's just a marvelous, marvelous organism, and understanding how it's able to do what it can do allows us to understand the biological world a little better," says Green. "So as long as they're performing the behavior, I'll be interested in overcoming the obstacles to understand it."

W

HY PROTECT the migration of North American monarchs? The answers, I found as I followed their journey, are almost as varied as monarch allies themselves. Some, like Green, are drawn to the butterfly's mysteries;

others admire its beauty and tenacity. Many monarch volunteers form international friendships that they come to value almost as much as the butterflies.

For Jane Breckinridge, co-founder of the Tribal Alliance for Pollinators, restoring monarch habitat is part of a broader endeavor to support species of all kinds, including humans. "Monarchs are special and magical, and I love them," she says. "But the problems they face are the problems faced by all our native pollinators and all our other native critters."

A citizen of the Muscogee Nation in northeastern Oklahoma, Breckinridge grew up in nearby Tulsa, then spent two decades in Minnesota before returning to live on her grandmother's land in 2004. There, she and her husband, David,

opened a commercial butterfly farm, cultivating an array of species for sale to zoos and museums. She started a program called Natives Raising Natives, which recruits tribal members to rear butterflies—and the native plants they need—at home for extra income. In 2014, Breckinridge asked University of Kansas professor Chip Taylor for help in restoring a monarch migration corridor on tribal lands in Oklahoma. Taylor, the founder of the volunteer monarch-tracking organization Monarch Watch, was enthusiastic; he knew monarchs badly needed more habitat in Oklahoma. But he suspected it would not be easy: Patches of native prairie are so rare that locally adapted seed supplies can only be acquired through labor-intensive collection.

Ten years later, the Tribal Alliance for Pollinators is the largest producer of native plants and seeds in Oklahoma, and it works with tribes throughout the Great Plains and beyond. Seeds from 230 native prairie species are available free to all tribal members, and each year the small staff distributes tens of thousands of young plants to individuals and institutions. Tribes throughout Oklahoma have documented breeding monarchs making heavy use of the milkweeds in their pollinator gardens, which also host native bees, small mammals, and other species. The plants benefit humans, too, for some have ceremonial significance or medicinal uses, and all are appreciated for their colorful variety.

The Muscogee Nation is home to two distinct Indigenous languages, Muscogee and Yuchi, and the latter is spoken by a few dozen people. That number, however, is growing: At the local immersion school, preschoolers and elementary students greet the day in Yuchi, then tend to the school's garden of native plants. During the winter of 2019, inspired in part by the work of

the Tribal Alliance for Pollinators, the school's staff and instructors crowded into a van and drove to central Mexico, where they trekked into one of the sanctuaries to see the butterflies that would, before long, be flying toward the Muscogee Nation.

For school co-founder Halay Turning Heart, who learned Yuchi as a child and now speaks it with her young children, the connection between her work and the monarch's migration is obvious. "We see the language as essential for our survival, and we know the butterflies are struggling for their survival," she says. "We recognize that they're fighting for their habitat and that we're helping to bring it back." The sight of the monarchs assembled in Mexico, she remembers, was both awe-inspiring and heart-wrenching: "We knew we might not see it again in the same way. We know how quickly things can change."

owhere is the enormous challenge of bringing back monarch habitat more obvious than in Iowa. The state's fertile soil grows more than two billion bushels of corn each year, almost all of which is used for livestock feed or ethanol production, and rural Iowa is

dominated by field after field of corn and soybeans. In 1996, when Monsanto began introducing genetically modified crops that are resistant to the herbicide glyphosate, or Roundup, farms across the Midwest started using glyphosate for weed control, killing milkweed and other benign natives in the process.

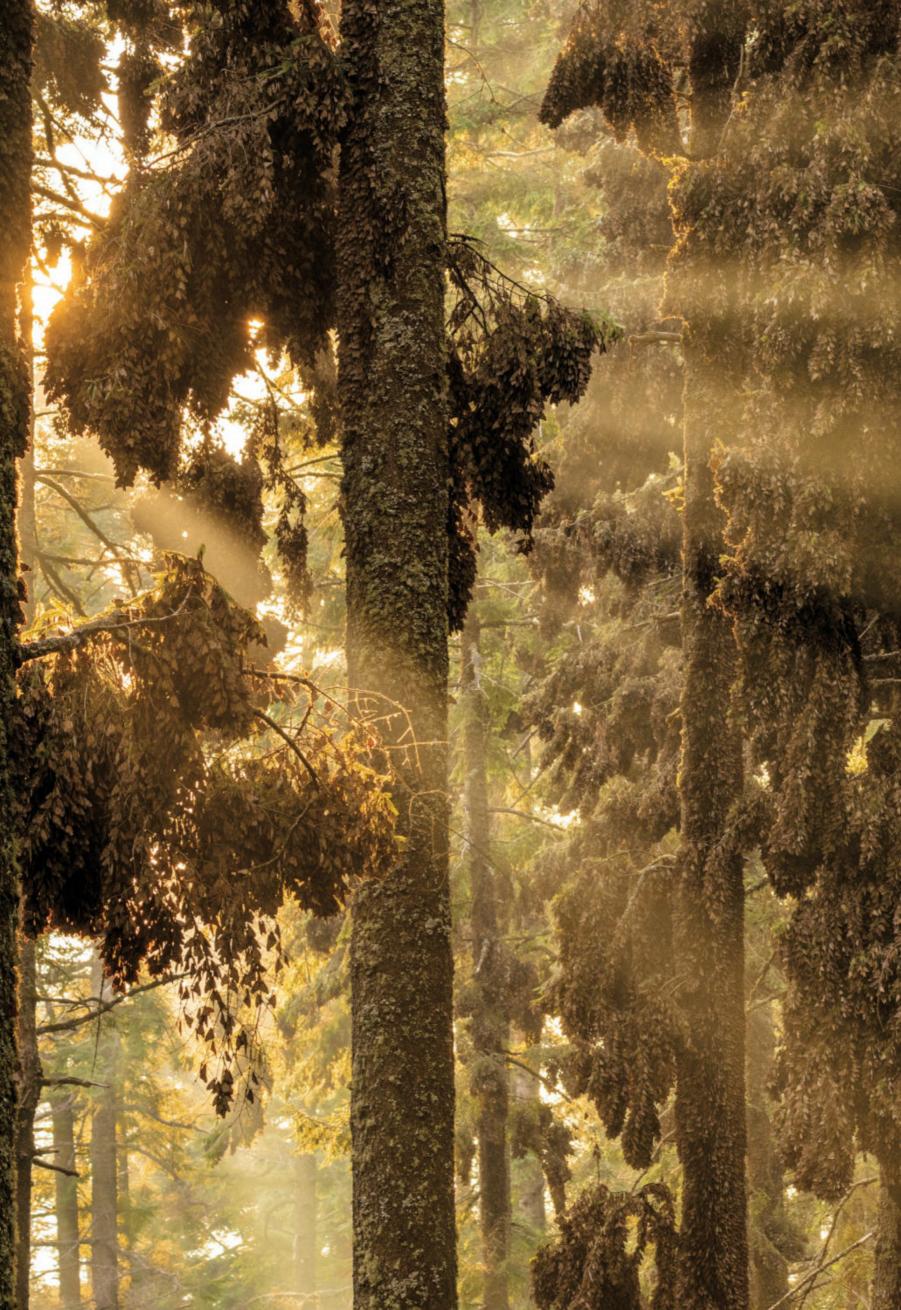
Today, native plants find refuge on the grounds of the Tallgrass Prairie Center at the University of Northern Iowa, where staff members tend neat rows of milkweed, spiderwort, and other species. The seeds for these plantings are collected in the state's vanishingly small remnants of native prairie, several located in the 19th-century cemeteries that were among the few places off-limits to settler plows. Every year, commercial seed, some produced from this genetically diverse stock, is distributed to the state's county road departments, which plant it on Iowa's road margins.

The program, started more than 30 years ago as an attempt to sustainably manage roadside vegetation, is now one of the most extensive habitat restoration efforts in the state. Iowa transportation officials estimate that about a quarter of the state's roadsides are planted with native grasses and wildflowers, and the plants frequently host monarchs and other insects. Throughout rural Iowa, county roadside managers serve as informal ambassadors for the value of native prairie, explaining that what may look like a stand of weeds in need of mowing is a low-maintenance, ecologically rich echo of prairies past.

But Iowa's roadsides cover only a tiny part of the state, and experts say that in order to reproduce at rates that will stave off extinction, North American monarchs require at least twice the amount of milkweed currently available in the entire Midwest—as well as reliable supplies of other nectar-producing natives along their migratory routes. "We need much more than one percent of the land area to counteract all that's been lost," says Laura Jackson, the director of the Tallgrass Prairie Center. The state has little public land—state-managed roadsides make up less than a fifth of it—so Jackson and the rest of the center's staff also work on private-land habitat restoration through the federal Conservation Reserve Program, which contracts farmland for conservation purposes.

In 2018, they began collaborating on a major restoration project with Cathy Irvine, a retired special-education teacher in northeastern Iowa, who has donated almost 300 acres of her family's corn and bean fields to the center as a tribute to her late husband, David. On a June afternoon, a pair of monarchs flits across 80 acres already thick with milkweed, wild indigo, purple coneflower, and other native flowers and grasses. "None of this will be planted again except as prairie," she says with satisfaction.

If Iowa embodies the difficulty of prairie restoration, the Irvine Prairie illustrates its possibilities. Getting the right combination of viable native seeds into hospitable ground is no small feat, and restoration practitioners are well acquainted with failure. "Humility is big around here," says Jackson. Plantings also require periodic burning or mowing to keep out woody species. Once prairie plants take root, however, valuable habitat can happen fast. Irvine and Jackson look forward to the day when seeds from these native species begin to sprout on nearby roadsides, setting forth into the landscape their ancestors called home.







A pair of monarchs finds a goldenrod plant to mate on in a prairie strip next to a soybean field on an lowa farm. The federally funded strips can be placed on the edge of a field or as an alternate row in the middle of crop plantings.

generation of monarchs in Mexico performs a final spectacular feat, flying hundreds of miles north to lay their eggs. During an April visit to the Muscogee Nation, I watch a single monarch, identifiable as female by her thick black wing yeins travel low over a suppaked putting green.

veins, travel low over a sunbaked putting green, the ragged edges of her wings a testament to her endurance. If she hasn't finished laying her eggs—several hundred in total, typically deposited one by one on the undersides of milkweed leaves—she will soon, for her life is nearly at an end. Her progeny, and theirs, will complete the trip north, flying as far as southern Canada.

This defunct golf course, acquired by the Muscogee Nation from a private owner, doesn't look much like butterfly habitat, but the monarch is snacking on nectar from a cluster of native plants, and more flowers will bloom soon. Collin Spriggs, a conservation botanist with the Tribal Alliance for Pollinators, parks his blue hatchback on the turf and unloads fragrant trays of lemon bee balm and mountain mint seedlings. Leading the small crew of planters is Muscogee Nation wildlife technician Brooklyn Bartling, whose left bicep is tattooed with images of a blackberry, a bee, and a ladybug.

Bartling excitedly describes the nation's plan to turn the course into a nature reserve, as well as



her work helping to remove invasive plants from the grounds and establish native wildflowers. "I'm taking pictures of butterflies, caterpillars, bugs—everything I see here," she says. "I want to get that information to the public, to put the why behind what we're doing."

She and Spriggs stand over a compass plant, a native perennial they've been keeping an eye on since planting it last year. Though it has just two leaves, Spriggs says, its taproot may already extend several feet into the subsoil, affording the plant access to water even during the current drought.

Bartling grins at the news and looks up to survey the fairway. "There's a lot of potential here," she says. "A lot of potential."  $\square$ 

#### Restoring monarch habitat, one yard at a time

In the United States, where lawns and other residential landscapes cover nearly 140 million acres, tens of thousands of people are turning their outdoor spaces into habitat for monarchs and other species. "This is a grassroots approach," says author and entomologist Doug Tallamy, co-founder of the organization Homegrown National Park. "You don't need anyone's permission to do it, and you get to enjoy the results."

To join the movement, says Tallamy, focus on supplying monarchs with their two basic needs: a place to breed and fuel for their long migration in the fall.

- Milkweed, which offers essential breeding habitat, is easy to grow in beds or container gardens.
- In general, select the milkweed species best suited to your climate, but note that researchers advise against planting tropical milkweed (Asclepias curassavica), especially in warm climates, because its year-round flowers may delay or interrupt migration.
- To provide monarchs with calories for their journey, choose native perennials that will produce blooms, and nectar, at different times throughout the growing season.

Ginny and Bill Nelson, who have transformed their quarter-acre Wisconsin yard into a homegrown prairie, advise backyard restorationists to start slowly.

Thirty years ago they established a single eight-foot-square bed of native plants. Year by year, they replaced more lawn and evergreen hedges with a cornucopia of native species.

On a summer afternoon, Ginny watched a monarch circle the flaming orange blossoms of a butterfly weed. "The butterflies have always been here," she said. "I just didn't know it."













## Two weeks before her 48th birthday, **Eboni Camille** Chillis lay in a hospital bed, ready to give birth to her first child.

As she nervously waited for the doctors to begin a cesarean section, she put on a playlist she had made for the occasion. It consisted of songs she found calming and empowering, such as Diana Ross's "I'm Coming Out," and "Lovely Day," by Bill Withers. With her phone next to her ear, she sang along. A few nurses joined in too.

Chillis had always wanted to be a mother. In her 20s and 30s she'd expected the rom-com ending. "I would fall in love, get married, have a baby," the Atlanta-based educator and entrepreneur told me. "And it didn't happen that way." When the pandemic forced her to slow down and reflect, she committed to having a child on her own. She was in her mid-40s. Based on her age and test results, she was told that the odds of conceiving with her own eggs were less than one percent, which led her to seek an egg donor. For a year she scrolled through profiles of egg and sperm donors, scrutinizing their baby photos, medical history, favorite films. After finding donors who felt like the right fit, it was time to prepare her uterus for an embryo transfer. She gave herself daily progesterone injections for two



Eboni Camille Chillis, 48, holds her newborn daughter in the baby's room in her Atlanta home. When Chillis decided to have a child as a single mother, she was faced with the reality of the shortage of Black sperm and egg donors. She co-wrote an article about the issue for Psychology Today. (Her daughter's name was withheld on request.)



weeks before the procedure and continued the shots throughout her first trimester.

Last January, Chillis's daughter was born, making her debut as Stevie Wonder's "Isn't She Lovely?" played. A nurse placed the baby on the new mom's chest, and her tiny mouth immediately began searching for Chillis's breast. When she latched, the uncertainty of the preceding years dissolved, and Chillis thought, We're going to be OK.

Chillis is part of a shift that's been under way for decades: More and more, people are postponing parenthood. In the United States in 1970, the average age of a woman giving birth for the first time was 21.4. By 2021, it was 27.3. According to the Centers for Disease Control and Prevention (CDC), from 1985 through 2022 the birth rate for women ages 40 to 44 rose almost continuously, from four to 12.5 births per thousand women. For women over 45, the rate remained low in 2022, at 1.1 per thousand women, but represented an increase of 12 percent from the previous year. (CDC data do not reflect that people who give birth have a range of gender identities.) Although





The first successful egg-donor birth was in 1984. It confirmed that age was not necessarily an impediment for the uterus, even after menopause.







#### TOP LEFT

Physician Mark Sauer stands in front of a projection of media clips from the extensive coverage he received in magazines and newspapers across the country for his assisted reproduction research and techniques that led to people giving birth later in life, even after menopause.

REBECCA HALE

#### BOTTOM LEFT

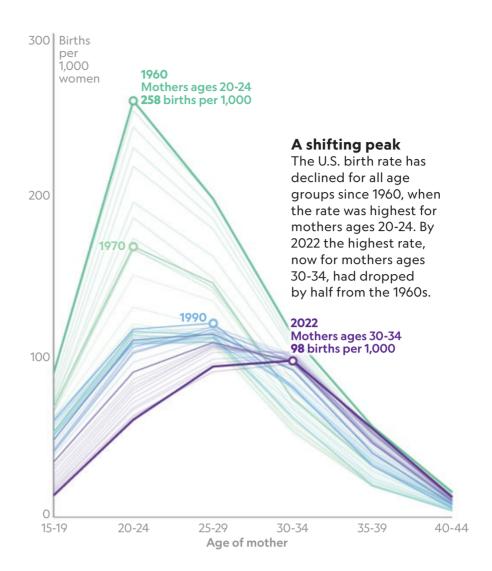
Bob Wilson, Barbara Strong (center), and their daughter Cristie look through articles that covered Cristie's birth in 1990. With Sauer as her doctor, Strong gave birth at 41 years old, using a donor egg because her ovaries were damaged by chemotherapy treatment for breast cancer. In addition to Cristie, the couple have 10 adopted children and one child through surrogacy.

#### THIS PAGE

Morgan Mitchell hugs his mother, Jonie Mosby Mitchell, who gave birth to him at 52. "He and I are really good friends," says Mosby Mitchell, now 84. The former country singer was Sauer's first patient to give birth after 50.

## Smaller Families, Starting l ater

Delayed marriage, contraceptive use, and changes in abortion access contributed to a steep drop in fertility rates in the United States in the 1970s, after the baby boom era. In recent decades, the decline has been driven by factors including more women entering the workforce and more women postponing childbearing.



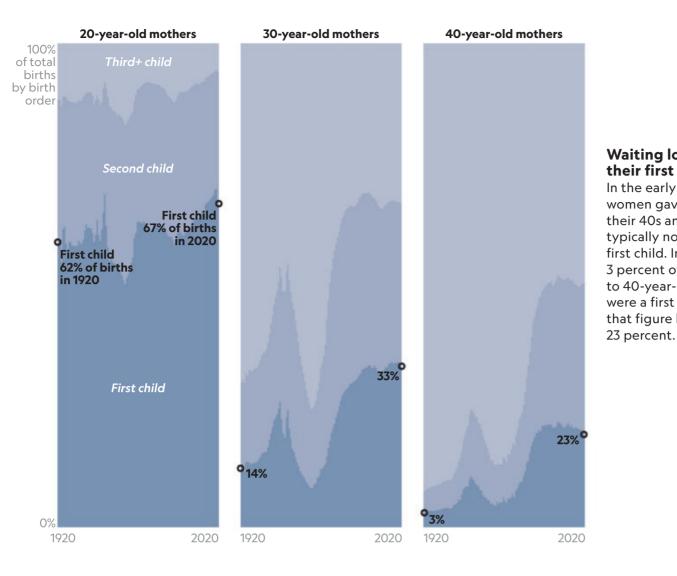
the numbers vary by country, many parts of the world show the same trend.

To be clear, some women have always had children later in life. In 1940 the birth rate in the U.S. for women 40 to 44 years old, and even for women over 45, was slightly higher than it was in 2022. But at the time, these births were typically the mother's third, fourth, or fifth child.

Today people are starting families later and in some cases without partners. It's a familiar story: People, often with access to more reliable contraception, prioritize education and careers—not to mention footloose freedoms before taking on the all-consuming responsibilities of child-rearing. Greater opportunities for women and evolving gender roles have been key factors. Meanwhile, assisted reproductive technologies such as in vitro fertilization (IVF) have enabled people to have children in circumstances where it previously would have been difficult. The result has been at least 12 million children born worldwide through IVF and a profound transformation of human reproduction. Now scientists are pursuing new lines of research that appear poised to revolutionize it even more.

THE FIRST BABY CONCEIVED through IVF was born on July 25, 1978, in Oldham, England. The procedure involves fertilizing an egg with sperm in a petri dish, creating an embryo that can be transferred into a person's uterus. It was initially used in cases of blocked fallopian tubes but proved capable of addressing other infertility issues. At the time referred to as "test-tube babies," children conceived by this method inspired fascination and alarm in the media and the public. Fears ranged from the possibility of birth defects to religious concerns about intervening in the reproductive process. But it didn't take long for the procedure to become common and widely accepted.

In some cases, a patient's eggs were not viable, due to age or other factors. So the medical field started exploring egg donation. The first successful egg-donor birth was reported in 1984. On February 3, a headline on the front page of the Los Angeles Times blared: "Woman Bears Donor's



Waiting longer for their first child In the early 20th century, women gave birth in their 40s and older but typically not to their first child. In 1920, only 3 percent of all births to 40-year-old mothers were a first child. By 2022 that figure had risen to

Baby"—phrasing that suggests some confusion about who was the mother. In March 1992, Jonie Mosby Mitchell, a former country singer, gave birth at 52 using an egg from a younger woman. At the time, she was reported to be the oldest mother in the U.S. to have a baby through IVF.

Mitchell already had four children from a previous marriage and an adopted daughter with her new husband, but wanted a baby with him too. When I spoke with her recently, she remembered reading in the newspaper about Mark Sauer, then a physician at the University of Southern California who was a pioneer of egg donation. She reached out to Sauer about having a baby at her age, and she recalled his response was, "You know, Jonie, there's no reason in the world you can't have one." She became a patient of Sauer's and delivered a son, Morgan. The birth was covered widely in the press. "Everybody was tickled," she said.

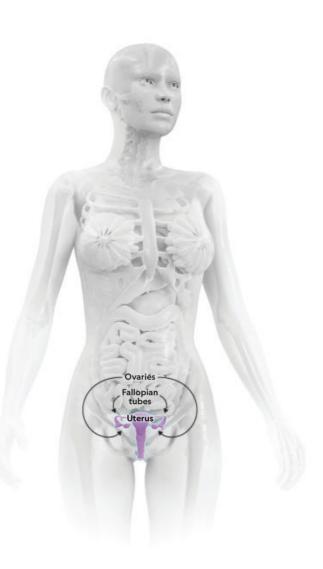
Successful egg-donor pregnancies confirmed that age was not necessarily an impediment for the uterus, even after menopause. The challenge lay in the ovaries, which age at a markedly accelerated rate compared with other organs in the body. Ovarian reserve refers to the quantity and quality of a person's eggs. Over time, the number of eggs sharply decreases, and those that remain accumulate DNA damage and chromosomal problems, making fertilization more difficult and miscarriage more likely.

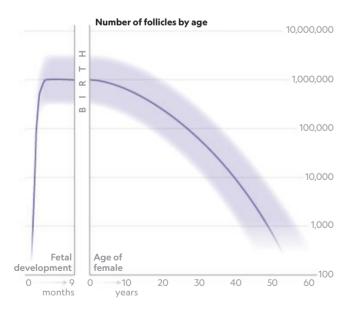
Sauer co-authored a series of articles in high-profile medical journals about his early IVF work, culminating in a 1993 *Lancet* paper titled "Pregnancy After Age 50." The ensuing media attention drew droves of new patients from around the world. Although he faced some backlash, he said it was gratifying to help people realize their dreams of parenthood. He recalled friends of his own children coming to his house and saying, "My mom said to tell you thank you for my brother."

THE COMPARATIVELY RAPID AGING of the ovary has long been a mystery. There are different theories as to why. "People talk about how there must be some evolutionary advantage to menopause, perhaps," said Rebecca Robker, a professor of

# Illuminating the Human Embryo

As a female ages, eggs and the embryos that develop from them run a greater risk of genetic abnormality. This can lead to infertility or miscarriage, risks that increase significantly after the age of 35. Recently, using fluorescent dyes and laser microscopes, researchers have captured the most detailed images ever seen of human embryos growing in a lab. This breakthrough imaging technique could help doctors improve embryo selection during the in vitro fertilization (IVF) process, leading to higher pregnancy and lower miscarriage rates.

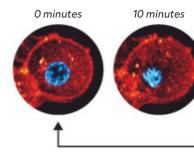




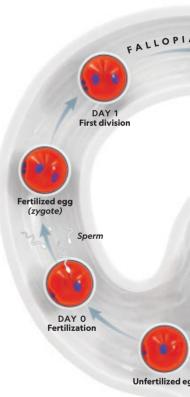
### The number of eggs females have is set at birth—and is depleted later in life.

Eggs eventually grow from a finite number of follicles that develop when the female is still a fetus. Some fetuses have more than a million follicles, all formed in the first months of fetal development. Once the menstrual cycle begins, follicles become eggs. As a female ages, her potential number of eggs is gradually depleted through ovulation and cell death. On average, there are about a hundred thousand of ollicles at the onset of puberty and a thousand at menopause.

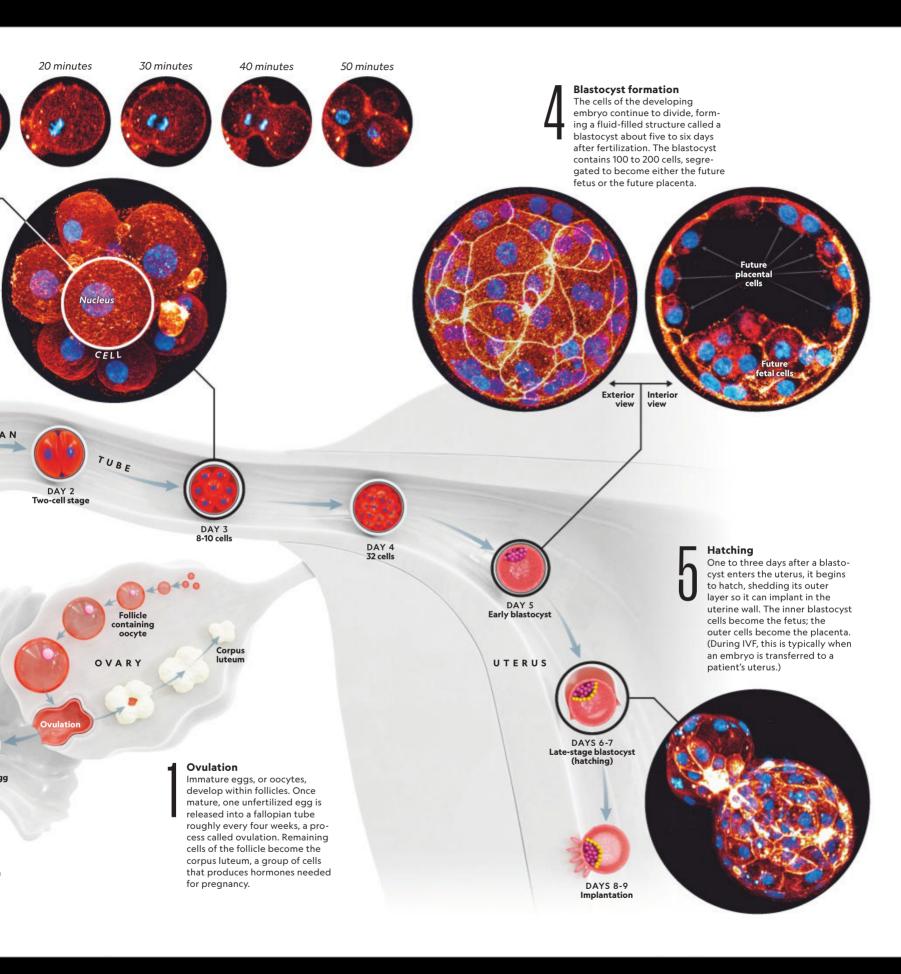
JASON TREAT, NGM STAFF.
KELSEY NOWAKOWSKI. ART: MAGIC TORCH
EMBRYO IMAGES: NICOLAS PLACHTA,
UNIVERSITY OF PENNSYLVANIA
SOURCES: ANA DOMINGO-MUELAS,
BLAKE HERNANDEZ, AND ROBIN SKORY,
UNIVERSITY OF PENNSYLVANIA



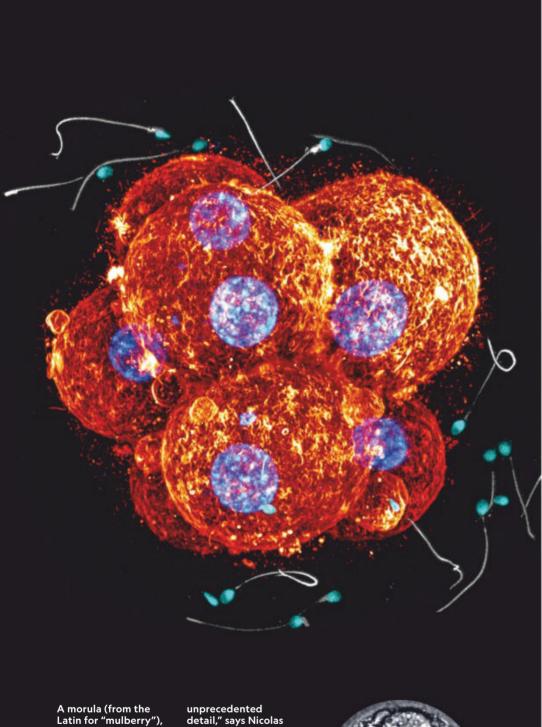
Cell division
The fertilized egg, called a zygote, continues to move through the fallopian tube. After about 30 hours it splits into two cells, then four cells, and so on, continually dividing roughly every 12 hours. DNA in the nucleus of the cells (pictured in blue) is copied and divided equally.



Fertilization
The tens of millions of sperm released during ejaculation swim through the uterus to the fallopian tubes, where fertilization and the first stages of embryonic development occur. The DNA from a sperm and the egg combine to form the genome of the fertilized egg.



What if scientis figure of to slow turn bad biological so that we could present the could present the



A morula (from the Latin for "mulberry"), a fertilized egg in the early stages of cell division, locks out late-arriving sperm. "This is the first time we can image every cell inside a living human embryo, interacting with each other and changing shape and position with

unprecedented detail," says Nicolas Plachta, a cell biologist at the University of Pennsylvania. Blue dye illuminates each cell's nucleus and DNA; orange reveals each cell's protective cortex. The gray image (at right) shows the limitations of conventional microscopes.



biomedicine at the University of Adelaide in Australia who studies female reproductive biology. "You know, like the grandmother hypothesis. Is it beneficial for societies to have these older, wise women assist in the families?" Another theory is that most humans didn't live much past 40 before medical advances lengthened life spans. But in that case, why do other organs remain healthy for longer, and why does sperm production continue?

The aging of the ovary itself is distinct from the decline in egg quantity and quality, but the two are related, albeit in ways scientists don't yet fully understand. And both relate to hormone production, which affects not just fertility but nearly all aspects of health, from cognitive functioning to bone density.

Egg donation as well as the increasingly popular practice of egg freezing can enable older women to use younger eggs, whether their own or someone else's. But what if scientists could figure out a way to slow down or turn back the biological clock, so that women could prolong their fertility while also reducing the negative health effects that accompany ovarian aging?

discovery was made in 2016 by Francesca Duncan, a professor of reproductive science, and her team at Northwestern University. They noticed that the ovary becomes stiffer, or "fibrotic," over time. "The ovary's very dynamic," Duncan said. There's a lot going on, including the growth of follicles (the structures that contain and nurture immature eggs, or oocytes), the rupture of a follicle to release an egg with ovulation, and the death and reabsorption of unreleased oocytes.

All of this activity means that tissue is constantly getting repaired, which can lead to fibrosis—essentially, scarring. Duncan and other scientists, including Robker, have been investigating possible therapies that could "soften" the ovary and extend fertility. A 2022 paper in *Science Advances*, co-authored by Robker, reported that existing antifibrosis drugs restored ovulation in 15-monthold mice, comparable to humans around age 50.

David Pépin, a reproductive biologist at Massachusetts General Hospital, is investigating a different angle. He's studying the little-known but important anti-Mullerian hormone (AMH), produced by follicles in the ovaries. He believes modulating AMH could, in effect, help switch fertility off and on. Pépin formulated a synthetic

ts could ut a way down or ck the al clock, women olong rtility?



Sarah McKnight, 42, is a commercial pilot and a single mother by choice. Using in vitro fertilization (IVF) and donated sperm, she had a daughter in 2019 and a son in 2021. McKnight sits with her daughter, who has a cold, as a humidifier releases mist. (Her children's names were withheld on request.)

version of AMH that he's tested on animals, including mice and cats. He discovered that at elevated levels, AMH prevents the activation of growing follicles. When a sufficient dose of the hormone is administered, he said, "you have very few follicles activate, and those that do are basically incapable of growing and maturing." As a result, AMH could act as a contraceptive. (He's developing a feline contraceptive to control feral cat populations, but it consists of a onetime injection, whereas the goal for humans is a daily pill.)

When treatment ceases, fertility may be restored and possibly even enhanced. The follicles resume growing, and because they've been accumulating for the duration of treatment, more follicles than usual grow concurrently. If someone with a dearth of eggs were to undergo IVF at that time, the odds of success could rise. AMH treatment could also interrupt some of that perpetual activity in the ovary, potentially diminishing the aging associated with it.

Scientists agree that no single solution will dramatically prolong fertility or ovarian health. But if research in several relevant areas bears fruit, it could add up to meaningful progress in the coming years. "We're at a point in time when there's a lot of eyes on this topic," said Duncan. For example, the Global Consortium for Reproductive





# 'I realized this is something I would have to do on my own if I wanted it to happen.' -SARAH MCKNIGHT







#### TOP LEFT

Sarah McKnight helps her daughter into her tutu while holding her son on her lap to breastfeed him. "I decided not to let the pandemic stop me from having another baby," she says. "I was home anyway, so I figured it was a good time to try again."

#### BOTTOM LEFT

Sarah pumps breast milk in the early morning. The nature of her job as a pilot means that she is often away for long hours. Before leaving for the day, Sarah spends time making sure her family will have what they need during her absence.

#### ABOVE

Betsy McKnight holds her granddaughter, who's upset her mom is leaving for work. Sarah spent about \$65,000 in fertility treatments, going through several IVF attempts and embryo transfers before carrying her first pregnancy to term.

Longevity and Equality was founded in 2019 to support research and foster a global network of scientists and clinicians to study the subject. The organization has distributed more than \$14 million to 48 researchers worldwide, including Duncan. They call their efforts "a moon shot initiative to tackle female reproductive aging."

**EVERY MORNING, EBONI CAMILLE CHILLIS** goes to the crib, hugs her baby, and thanks her for being her daughter. Although the path to parenthood was different from what she'd envisioned, Chillis has come to embrace it. "There's a wholeness and happiness to me that I don't know that I've ever experienced," she said.

Other people who've had children through IVF later in life are similarly enthusiastic. "It is awesome," said Susie Troxler, who gave birth at age 50, using a donor egg and her husband's sperm after the couple tried to conceive on their own for almost a decade. "If it weren't for that technology, we wouldn't have been parents at all."

Yet some researchers and clinicians add a note of caution about delaying parenthood, even as their own work has contributed to the shift. One of the biggest risks is that the joyful endings don't always materialize. Sauer said that the high-profile success stories can obscure "the reality of how difficult it can be to achieve." According to the CDC's most recent data, the percentage of live-birth deliveries from IVF cycles by patients of all ages was 37 percent in 2020. The rate drops significantly for IVF patients over 40. (Using younger donor or frozen eggs improves one's chances, of course, but there are still no guarantees.) IVF is a costly procedure, often not covered by health insurance. The successes may give people misleading reassurance that they can always wait.

The risks of aging apply to men as well. "Men's sperm quality declines significantly over 40 and continues to decline," said Pépin. Although these sperm may still fertilize an egg and result in a successful pregnancy, DNA damage can result in adverse health outcomes for a child.

There are many reasons people postpone having children, and one of them is lack of social support. Robker noted that with more family-friendly government policies—affordable childcare and paid leave—some might choose to start their families at a younger age. "I can't do anything about the policies, so I'm working on how do we help people have the best ovary health for both their

'If it weren't for that technology, we wouldn't have been parents at all.'

-SUSIE TROXLER



Susie Troxler plays with daughter Lily, who's almost two years old, in Lily's bedroom. "The baby doesn't know that you're 50, nor does the baby care," Troxler says. "You're gonna have to chase them just as if you're 25."

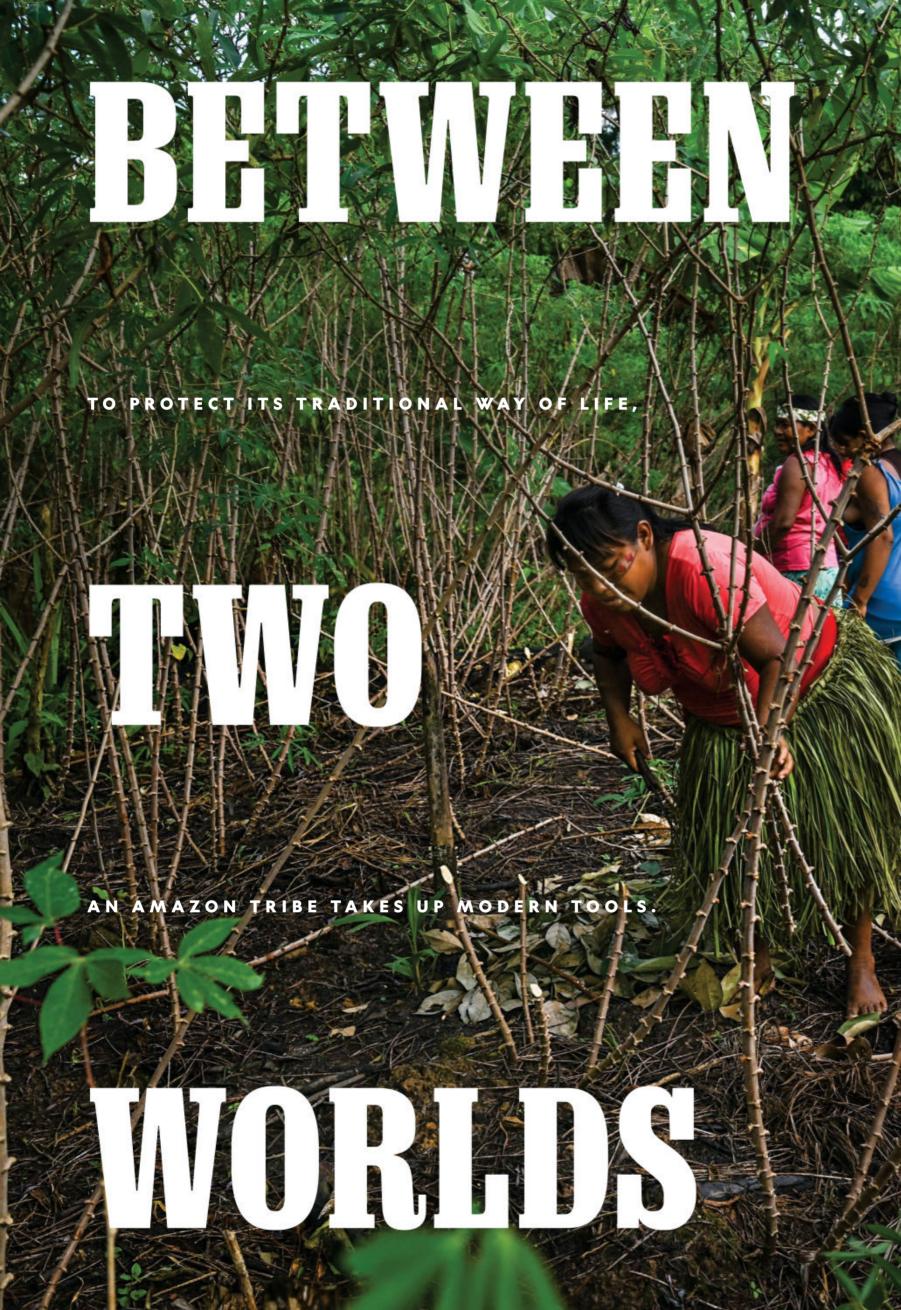


fertility and their overall health," she said.

Beyond ovarian health, significant research is under way on more futuristic concepts. A process known as in vitro gametogenesis (IVG) involves creating gametes from stem cells—for example, deriving an egg from another kind of cell, such as a skin cell. IVG could enable same-sex couples to have children with genes from both parents; it could allow more than two people to reproduce together. There's also the possibility of growing a fetus outside of a uterus in a synthetic womb.

Robker expects reproduction to change dramatically in the coming years. "People feel very, very passionate about having biological children," she said. "So that is pushing the boundaries on the development of new technologies that can facilitate generating embryos."

IVG and artificial wombs are likely still years, if not decades, away. But as these new tools evolve, vexing medical and ethical dilemmas are bound to follow. There are many risks, to be sure, yet there have already been many rewards from current reproductive technology: millions of parents who are grateful to have children when that hadn't seemed possible. "She's the light of our world," Troxler said of her daughter, Lily. "She's here when she's supposed to be here, to do what she's on the planet to do." □







as it flows deep into the Amazon forest. The only signs of human life along the waterway are the occasional boat or dock on the Peruvian side. On the Brazilian bank, government signs warn that this is Javari Valley Indigenous land, a reserve that's home to the highest concentration of isolated Indigenous peoples in the world. Outsiders are forbidden to enter, but the lure of abundant minerals, timber, and wildlife is impossible for many to resist.

Some 6,000 people are known to live in the reserve, an area of nearly pristine forest roughly the size of Portugal. But that number accounts only for members of seven tribes who have established contact with the outside world. I've come to see how these people, who live on an embattled frontier, are faring as illegal logging, fishing, and mining chip away at their ancestral home.

The village of São Luís sits about 200 miles up the Javari River from the town of Atalaia do Norte. It's home to 200 or so Kanamari people, who have granted me and a film crew permission to visit. For eight days we live in their tidy

The nonprofit National Geographic Society, working to conserve Earth's resources, helped fund this article.



**PREVIOUS PHOTO:** In the Javari Valley, one of the most isolated regions of the Amazon in Brazil, Kanamari women harvest manioc, a tuber that's a staple of their diet. The Kanamari mostly live off the land, but they and the forest that sustains them are threatened by outsiders eager to reap the Amazon's natural resources.



**ABOVE:** The Brazilian government first contacted the Kanamari in 1972, but the tribe likely encountered rubber tree tappers much earlier. Although decades of contact has affected many aspects of their lives, people in

the village of São Luís still do most things communally, from fishing to taking a dip in a swimming hole located on a tributary of the Javari River. The villagers are curious about their more isolated neighbors, including

one tribe that lives only 10 miles away in the forest. Hunting parties sometimes spot signs of them but don't attempt to communicate. Still, several Kanamari expressed a wish for a drone to see how their neighbors live.





The young in São Luís are raised traditionally, though a few, such as João Kanamari (right), are sent to the town of Atalaia do Norte—nine hours away by boat—for additional education. João uses his cell phone to document the

village's anti-poaching and logging patrols, as well as to communicate with other Indigenous communities and share snapshots on social media. Teresa Kanamari, wife of Chief Mauro Kanamari, adorns her grandson Permelo in a headdress and paint (top). Young people face off in a game similar to rugby but with dancing and chanting (above). A type of pineapple serves as a ball, and the game often culminates in a wrestling match.



settlement of wooden stilt houses, rising when Chief Mauro Kanamari (the Kanamari take the tribe's name as their last name) blows a horn. We accompany the women as they harvest manioc, or cassava, and the men as they hunt and fish.

What we witness, again and again, are people who, worried about violent incursions into their forest, are increasingly finding new ways to defend their land and their way of life.

"There used to be only a few illegal invaders, fishermen, and loggers who took wood from our territory," Chief Mauro tells us. "Now they are more with every day."

For the Kanamari, the forest is their parent who supplies everything. Logging and other natural resource extraction threaten their parent's health and their own livelihood. But it's dangerous to oppose such activities. In 2022 Brazilian Indigenous advocate Bruno Pereira and British journalist Dom Phillips were brutally murdered on another river in the region, allegedly by order of the head of a criminal fishing network. "I've personally received many threats," says Chief Mauro.

Still, the Kanamari refuse to allow these encroachments to go unchallenged. They've joined forces with FUNAI, Brazil's Indigenous affairs agency, and UNIVAJA, a union of the Indigenous groups in the Javari Valley, to organize vigilance patrols and push back against the outlaw loggers. FUNAI supplies radios and fuel for a motorized boat, but the Kanamari's weapons—bows and arrows and small-caliber guns—are no match for those of the intruders. By necessity, their philosophy is to be nonconfrontational but to report what they find.

"We used to confiscate this wood, but now, since they're coming in greater numbers, we've become afraid," says Chief Mauro. "When you go to the city, then you're marked for assassination."

João Kanamari, Chief Mauro's 20-year-old nephew, documents the patrols on his cell phone and shares the information on social media. In his late teens he was sent to Atalaia do Norte to learn Portuguese and serve as an interlocutor between his people and the rest of the world.

"We want the world to see us so they can help us," João says. "We are out here on these dangerous waters patrolling our territory, not just for us but also for you. The Amazon is our government, our father, and our mother. We can't survive without her, and, from what we all now understand, neither can you."

—As told to Rachel Hartigan













To harvest acai berries, a nutrient-rich part of the tribe's diet, Romario Kanamari (top, front) climbed a palm tree with a machete in his mouth, leaving the tree mostly intact. When loggers harvest trees,

they fell them with chain saws, targeting valuable hardwoods such as *ipê*, cherry, and mahogany. A barge consisting of poached wood from the Amazon (right) floated openly down the Javari River near São

Luís, likely destined for a sawmill. Usually such barges travel at night, but Addario and her team saw three on the river in broad daylight. A worker (above) slices a log at a sawmill in Altamira, Pará state, in northern Brazil.









## A FRAGILE FABRIC OF LIVING THINGS

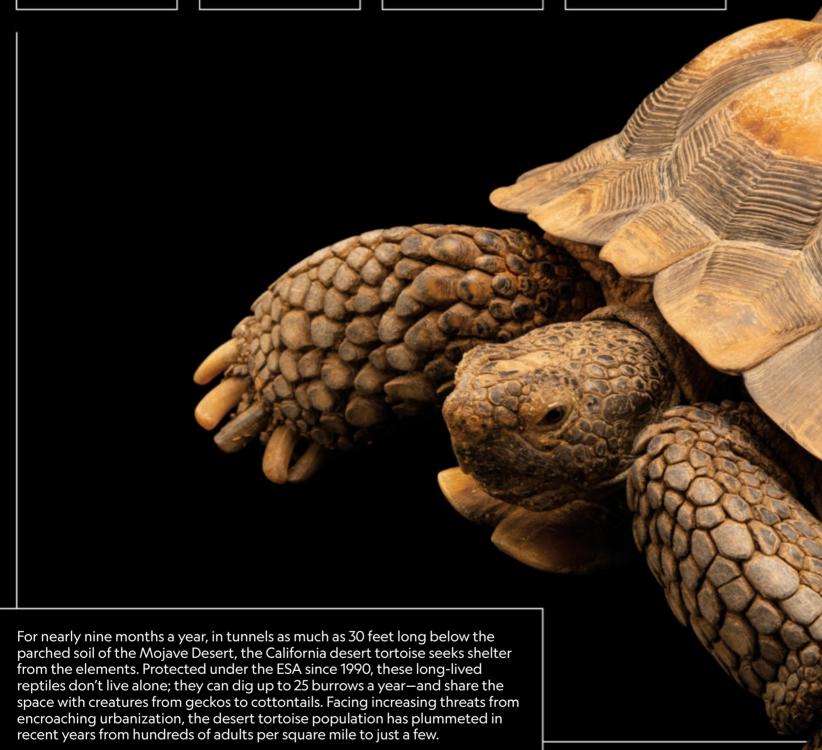




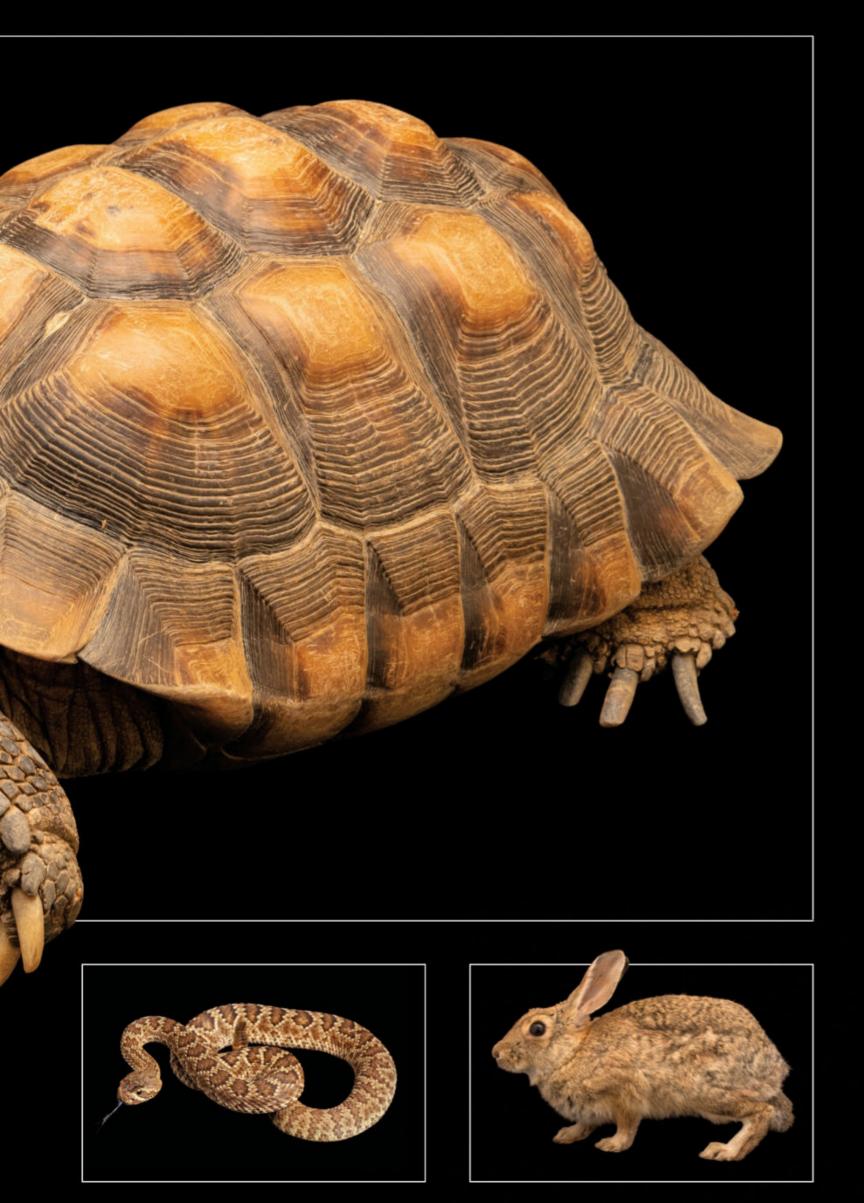
## THREATENED SPECIES CALIFORNIA DESERT TORTOISE

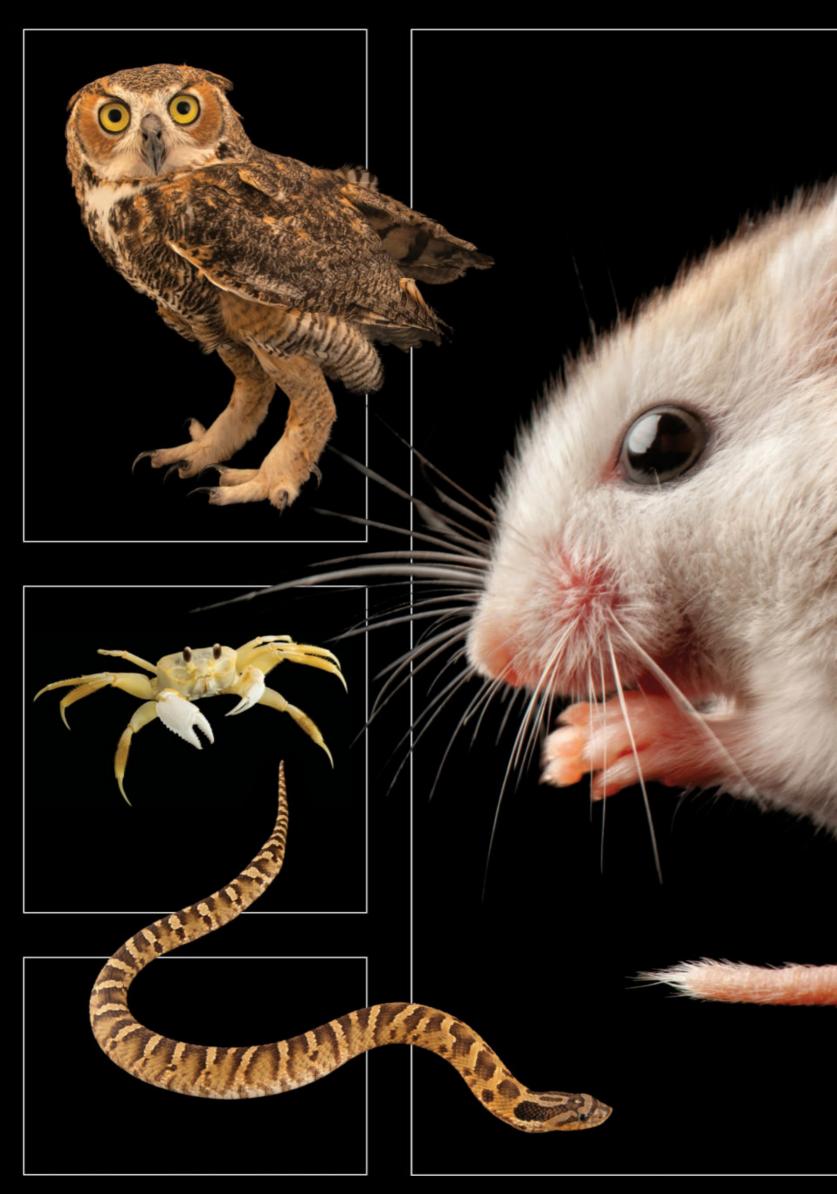
WESTERN BANDED GECKO DESERT Wood Rat MOJAVE RATTLESNAKE

DESERT COTTONTAIL









Counterclockwise from right: Peromyscus polionotus peninsularis, U.S.Fish and Wildlife Service, Panama City, Florida; Bubo virginianus virginianus, Wildlife Center of Texas; Ocypode quadrata, Gulf Specimen Marine Lab, Florida; Heterodon platirhinos, Houston Zoo

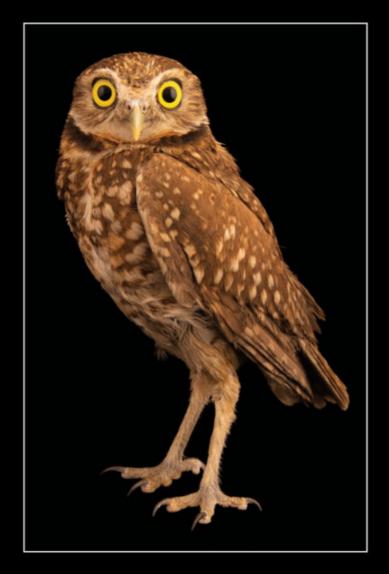


About four square miles of sand dunes on Florida's Gulf Coast are home to several species of endangered mice, including the St. Andrew beach mouse. These big-eared critters, only a few inches long, are threatened by a host of pressures, such as hurricanes, artificial lighting, and invasive predators. Protecting the beach mouse means preserving an important food source for owls, snakes, ghost crabs, and other native species.















## TREASURE ISLAND

STORY AND PHOTOGRAPHS BY

JASPER DOEST



The Netherlands' Rottumeroog is located in the Waddenzee, a tidal wetland that connects to the North Sea. The island is a vital rest stop for hundreds of thousands of migrating birds.



**Previous photo:** I captured this image of dune formations on a typical Dutch autumn day, with heavy rain showers alternating with low-lying sun. When I paid close attention, I realized that no two minutes there were the same.

he island of Rottumeroog in the Netherlands is an uninhabited wilderness heavily protected by European nature laws. In 2012 and 2013, I traveled there back and forth multiple times for an assignment, spending a total of 50 days and nights—an amazing oppor-

tunity, as visitors were usually prohibited. For much of my time there, I was alone. My job was to take pictures to help others learn about this place. But about two-thirds of the way through, a lesson emerged. It came by way of a message in a bottle, tossed from the sea.

I grew up near the Dutch coast, and Rottumeroog's flat, open setting was familiar to me. I tried to avoid imposing my own narrative on the island, which has a sand foundation and is gradually drifting to the southeast, guided by the current. So I walked its perimeter daily, training myself to listen and watch for small changes in this landscape that was so simple, you could draw it with just a few lines.



Marram grass, also known as European beach grass, plays a crucial role in coastal protection. Its long roots help stabilize



and bind sand, creating dunes that act as natural barriers against storm surges and tidal forces.

One of my favorite spots to explore was along the shore where an old building once stood. All that remained were some half-buried bricks, among which shells and ocean debris collected. One day I noticed a bottle in the rubble unlike others I'd previously found—this one's cap was screwed on. I opened it and discovered a handwritten note inside. In English, it said: "My name is Meike and I'm 11 years old. I have good friends and you?"

As I began writing back—Meike had given her school in the Netherlands as a return address—I tried to describe how humbling it was to be isolated in a densely populated part of northern Europe: On Rottumeroog you see only earth, water, and sand, and the wind whistles in your ears. Meike eventually received my letter, and now, years later, I am still in touch with her family. People tend to think that being alone is a bad thing. But to me it felt like freedom in every vein.

<sup>—</sup>As told to Catherine Zuckerman



Left: Shells create mesmerizing patterns shaped by wind and time.

Below: During one of my last visits I realized I needed images of myself to help people understand my solitary experience.
I directed this
shot of me carting equipment across the beach while my assistant held the camera.

ANTHEA DEN HOLLANDER





If you go to a place with pre-imposed ideas about it, you'll look for something that might not be there. In the flat expanse



of Rottumeroog, I learned to get out of my own way, to explore, and to let the island teach me what it had to say.



#### INSTAGRAM

### **REUBEN WU**

#### FROM OUR PHOTOGRAPHERS

#### wно

A Chicago-based artist, photographer, and musician WHERE

Bisti/De-Na-Zin Wilderness, New Mexico

Phase One XF camera with a 35mm lens

Wu's Lux Noctis project—Latin for "light of the night"—has taken him around the world to photograph familiar landscapes in new ways. He'll often deploy drones and LED panels to "paint" a scene during an exposure that can last several seconds or even minutes. One evening in the remote badlands of New Mexico, Wu found a grouping of eroded rock columns known as hoodoos. He captured two exposures, then merged them into this composite  $% \left( x\right) =\left( x\right)$ image of an otherworldly, rose-colored vision.

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